Life History Characteristics of Freshwater Fishes Occurring in British Columbia, with Major Emphasis on Lake Habitat Requirements

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LIFE HISTORY CHARACTERISTICS OF FRESHWATER FISHES OCCURRING IN BRITISH COLUMBIA, WITH MAJOR EMPHASIS ON LAKE HABITAT REQUIREMENTS

by

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ABSTRACT

Roberge, M., T. Slaney, and C.K. Minns. 2001. Life history characteristics of freshwater fishes occurring in British Columbia, with major emphasis on lake habitat characteristics. Can. Manuscr. Rep. Fish. Aquat. Sci. 2574: 189 pp.

Habitat requirements, specifically the lake habitat requirements, of 81 species and 13 additional subspecies and forms of freshwater fish that exist in British Columbia were summarized. Of the 94 freshwater species/subspecies, 78 occur in lakes for at least part of their life cycle. The remaining 16 species/subspecies either do not frequent lakes, or there was not sufficient information available on their lake habitat requirements. The life cycle stages defined in this report include the spawning period, young-of-the-year, juvenile and adult stages. Three habitat characteristics were summarized for each life stage. These include depth, substrate type and cover type. Overall, there is a general lack of information pertaining to the lake habitat requirements for the majority of the fish species that are found in BC. In particular, research and information on lake habitat requirements is lacking for the minnows, suckers, sculpins, lamprey, sticklebacks, and white sturgeon.

RÉSUMÉ

Roberge, M., T. Slaney, and C.K. Minns. 2001. Life history characteristics of freshwater fishes occurring in British Columbia, with major emphasis on lake habitat characteristics. Can. Manuscr. Rep. Fish. Aquat. Sci. 2574: 189 pp.

Cette étude porte sur les besoins en matière d'habitat, en particulier les besoins en matière d'habitat lacustre, de 81 espèces et 13 sous-espèces de poissons fréquentant les eaux dulcicoles de la Colombie-Britannique. De ces 94 espèces et sous-espèces, 78 séjournent en milieu lacustre pendant au moins une partie de leur cycle de vie, les 16 autres ne fréquentant pas les lacs ou n'ayant pas été suffisamment étudiés pour qu'on possède des renseignements intéressants sur leurs besoins en matière d'habitat lacustre. Les stades biologiques définis dans ce rapport comprennent les stades de frai, d'alevin, de juvénile et d'adulte. Trois caractéristiques d'habitat ont été étudiées pour chaque stade biologique : profondeur, type de substrat et type de couvert. Dans l'ensemble, on manque d'information sur les besoins en matière d'habitat lacustre concernant la majorité des espèces de poissons trouvées en Colombie-Britannique, en particulier les menés, meuniers, chabots, lamproies, épinoches à neuf épines et esturgeons blancs.

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INTRODUCTION

The destruction and misuse of fish habitat is one of the known causes that contribute to the decline of many freshwater fish species (Slaney et al. 1996, Minns 1997). Fisheries and Oceans Canada is exploring methods of measuring, predicting and compensating for the affects of development projects that alter or destroy fish habitat (Minns 1997). Knowledge of the habitat use of fish species is vital when assessing the potential affect of proposed habitat alterations on local fish populations. In this paper, we summarize the available literature on the lake habitat use of fish species that are found in British Columbia. We have summarized the known habitat requirements of four life history stages (spawning, young-of-the-year, juvenile, and adults), and three habitat characteristics (water depth, substrate, and cover). Although this paper focuses on habitat requirements at specific life history stages, there is also mention of the general ecological interactions among species, which is also important to understand when managing species.

It was our goal to summarize habitat use and requirements for each species from observations specific to British Columbia. In many cases, especially with introduced species, the majority of information comes from other areas. When possible, specific studies done within British Columbia are mentioned. In other cases, many of the species found in British Columbia are not well studied or understood (e.g. leopard dace), and very little information is currently available. As a result, the information we present is not necessarily complete. Future research will increase our knowledge base for many of these less understood freshwater fish species.

METHODS

This report is the result of an extensive literature search for information pertaining to the lake habitat requirements of various life history stages of fish species occurring in British Columbia. The scientific name of each fish species follows Robins et al. (1991) (exceptions are noted in the text). The life history stages explored are spawning, young-of-the-year, juvenile, and adult. The spawning stage is when adults become reproductively active and move to a specific area to release gametes into the water for incubation. The young-of-the-year stage is the first year of life of the fish. It essentially begins once the fish has hatched from the egg and ends one year from that moment. The juvenile stage represents a fish older than one year that is like an adult in appearance, but is smaller and is not sexually mature. The adult stage is when a fish becomes sexually mature and has the potential to reproduce.

Databases searched include:

- numerous reference texts and materials such as Carl et al. 1967, McPhail and Lindsey 1970, Scott and Crossman 1973, Morrow 1980, Groot and Margolis 1991, Ford et al. 1995, Cannings and Ptolemy 1998, Haas 1998, Bradbury et al. 1999;
- refereed journals including Journal of Canadian Fisheries and Aquatic Sciences (Journal of Fisheries Research Board of Canada), Transactions of American Fisheries Society, North American Journal of Fisheries Management, Canadian Field-Naturalist;
- Pacific Salmon Commission library, Vancouver, BC;
- Ministry of Fisheries website and reference lists;
- Canadian Fisheries and Aquatic Sciences Technical Reports;
- Fisheries Technical Circular Reports;

- Campbell et al. 1998 summary for COSEWIC (Committee of the Status of Endangered Wildlife in Canada).

A written summary of the habitat requirements and general behaviours at each life history stage for each species and subspecies found in British Columbia is included. Major emphasis in the written summary is given to lake habitat requirements. Each written summary is accompanied by a table that contains information pertaining strictly to lake habitat requirements at each life stage. Lake habitat variables included in the table are, water depth, substrate type, including limnetic (i.e. open-water areas not associated with the bottom or shore), and cover type.

WATER DEPTH

A total of five water depth categories are used, 0-1, 1-2, 2-5, 5-10 and > 10 m. Depth represents the distance from the surface of the water downwards. For example, if a limnetic fish is found offshore water within the top metre of water, then 0 – 1 m is reported as a depth preference for that species. Depth was reported exactly as stated in the reference, but if 'shallow' water was the only descriptor, a depth of 0–5 m was used to represent 'shallow' water.

SUBSTRATE TYPE

Substrate composition was reported exactly as stated in the reference, however, if particle size was provided, substrate type was classified according to Johnston and Slaney (1996).

COVER TYPE

Cover is defined as 'features within the aquatic environment that may be used by fish for protection (or refuge) from predators, competitors and adverse environmental conditions' (Bradbury et al. 1999).

Cover is defined by the following features:

- submergent vegetation – aquatic plants that grow entirely below the water's surface (e.g. bladderwort);
- emergent vegetation – aquatic plants that are rooted within submerged areas, but the stem and leaves are above the surface of the water (e.g. cattail, reeds);
- overhead – riparian cover overhanging the littoral zone, undercut banks and woody debris at the surface of the water;
- *in situ* – rocks and boulders on a sand/gravel substrate, submerged woody debris, etc.;
- other which included any type of cover not defined above.

Association by each life stage with depth, substrate and cover features is rated using the following system.

- high (H) – species is nearly always associated;
- medium (M) – species is frequently associated;
- low (L) – species is infrequently associated;
- Nil – species is not associated;

- blank space – no information was available to rate association;
- *italicized rating* – no information was available, however rating is based on association during a different life stage, on feeding/diet information and/or on riverine habitat association.

RESULTS

A total of 81 species and 13 subspecies/forms were summarized in this report. The subspecies/forms included in this report are unique to British Columbia and are of high conservation value (Cannings and Ptolemy 1998, Haas 1998). This report excludes all hybrid species that exist within British Columbia, including the northern redbelly X finescale dace (Haas 1998). Fifteen of the species are introduced to the province. All species included in this report are listed in Table 1. A map of British Columbia that highlights the major watersheds and waterbodies is presented in Figure 1. Of the 94 species and subspecies/forms included in this report, 78 enter lakes for at least a portion of their life cycle and 15 species and subspecies/forms never enter lakes.

The times listed for spawning, egg incubation, emergence, movement between nearshore and offshore areas, and diel movements are approximate, and in many cases are based on laboratory experiments. Natural environmental variability in temperature, water depth, flow velocity and day length among locations and years will determine the exact timing of such events.

The following sections summarize the habitat requirements of the species and subspecies found in British Columbia, with an emphasis on lake habitat requirements. Following the text, the lake habitat requirements for each life stage of the species that inhabits lakes is summarized in tabular form.

LAMPREYS (*PETROMYZONTIDAE*)

RIVER LAMPREY (*LAMPETRA AYRESI*)

In 1958 the river lamprey of North America was described as a distinct species from the European river lamprey *Lampetra fluviatilis* (Vladykov and Follett 1958). *Lampetra ayresi* are restricted to the Pacific coast of North America between the Skeena River, BC, to San Francisco Bay and the Sacramento River, California (Scott and Crossman 1973, Docker et al. 1999).

River lamprey are anadromous (Scott and Crossman 1973, Docker et al. 1999). They migrate up rivers to spawning grounds starting in July (Beamish and Youson 1987) and probably spawn over gravel (Scott and Crossman 1973). In California they were documented spawning between the end of April and May. The ammocoetes burrow themselves in the mud of rivers and remain in freshwater for an unknown period of time after which they begin metamorphism into adults. Ammocoetes will feed on microscopic plants and animals while in the river (Scott and Crossman 1973). Metamorphism usually begins in July and may take until April to complete (Beamish and Youson 1987). River lamprey are parasitic (Docker et al. 1999), and feed on fish, particularly Pacific salmon and herring in the Strait of Georgia and low Fraser River (Beamish and Youson 1987, Beamish and Neville 1995). A single river lamprey was caught during the winter at a depth of 40 m in Nimpkish Lake on Vancouver Island (Simpson et al. 1981). River lamprey were captured during midwater trawls in Cultus, Kitsumkalum, Lakelse and Harrison lakes (J. Hume, Fisheries and Oceans Canada, 4222 Columbia Valley Highway, Cultus Lake, BC, V2R 5B6 personal communication).

VANCOUVER ISLAND (LAKE) LAMPREY (*LAMPETRA MACROSTOMA*)

The Vancouver Island lamprey, or known as the lake lamprey, has only recently been considered a distinct species from *Lampetra tridentata*, the Pacific lamprey (Beamish 1982, Robins et al. 1991). This species is smaller than the Pacific lamprey and is non-anadromous (Cannings and Ptolemy 1998). The Vancouver Island lamprey has a very restricted distribution in only two lakes on Vancouver Island, BC, Cowichan Lake, and Mesachie Lake (Cannings and Ptolemy 1998, Docker et al. 1999). Because of its limited distribution, COSEWIC (Committee of the Status of Endangered Wildlife in Canada) has listed the Vancouver Island lamprey as a vulnerable species in Canada (Campbell 1998), while the Conservation Data Centre (CDC) of British Columbia has listed it as an endangered or threatened species (RED listed) (CDC 2000). Vancouver Island lamprey are parasitic (Docker et al. 1999) and feed on salmonids within the two lakes (Beamish 1984, 1987).

Both the Pacific and Vancouver Island lamprey exist in these two lakes, however Vancouver Island lamprey may spawn later and in the lake compared to Pacific lamprey which spawn in streams (Beamish 1982, 1984, 1987). Spawning has been documented in the shallows over gravel at the mouth of several small creeks flowing into the lakes, but also may occur in deeper waters. Spawning takes place during May to August with adults dying shortly afterwards.

Ammocoetes will live up to six years before transforming into adults between July to October (Beamish 1984, 1987). Adults become sexually mature two years after metamorphism and so total life span is about eight years (Beamish 1984, 1987).

WESTERN BROOK LAMPREY (*LAMPETRA RICHARDSONI*)

Vladykov and Follett (1965) described the western brook lamprey as a distinct species from the eastern brook lamprey, *Lampetra planeri*. Western brook lamprey have a limited range. They are found in coastal streams in western North America from BC, including King Island and the southeastern corner of Vancouver Island south to Oregon (Scott and Crossman 1973, Docker et al. 1999). In BC, western brook lamprey are found frequently in Cultus Lake (Scott and Crossman 1973). In BC, they have been Red listed (endangered or threatened species) by the CDC (CDC 2000). Lake habitat requirements for this species are largely unknown.

Western brook lamprey are non-parasitic and live in freshwater (Docker et al. 1999). Adults spawn between late-April to early-July (Pletcher 1963, Scott and Crossman 1973) at temperatures above 10°C (Pletcher 1963). Males make the nest in coarse gravel and sand at the heads of riffles in streams (McIntyre 1969). Eggs hatch within 15 days at 15°C (Pletcher 1963). Ammocoetes burrow in the mud and silt at the stream margins and remain there for up to six years (Pletcher 1963). Ammocoetes metamorphose into adults between August and November, and the adults do not feed at all before spawning the next spring (Scott and Crossman 1973).

PACIFIC LAMPREY (*LAMPETRA TRIDENTATA*)

In BC, Pacific lamprey migrate far into major river systems, including the Columbia River and the Fraser River drainage to Shuswap Lake (Scott and Crossman 1973). Pacific lamprey inhabit Pacific coastal waters from the Aleutian Islands, Alaska to southern California (Scott and Crossman 1973, Docker et al. 1999). They are also present in Asia, ranging south to the Yuhutu River, Hokkaido, Japan (Scott and Crossman 1973). Pacific lamprey are able to move long distances upstream over obstacles such as rocks, dams and fish-ways by way of their suction disc (Scott and Crossman 1973).

The Pacific lamprey is anadromous (Docker et al. 1999). Adults begin their upstream migration between July and September and migration continues to late-May or early-June the following year (Beamish and Levings 1991). Pacific lamprey do not become sexually mature until October to March (Scott and Crossman 1973), and spend between seven to nine months in freshwater before spawning (Beamish and Levings 1991). During this stream residency period, they hide under rocks and do not feed (Scott and Crossman 1973). Spawning takes place from April to July in headwater streams and rivers over sandy gravel at the margins of riffles. Pacific lamprey die soon after spawning, although some populations in Washington State are known to spawn more than once (Page and Burr 1991).

Eggs hatch within 20 days at 15°C (Pletcher 1963). Larvae emerge from the gravel within two to three weeks and move passively downstream to soft bottomed areas where they burrow in the silt, mud, sand, or leaf bottom (Pletcher 1963, Scott and Crossman 1973). They spend up to four to six years in the mud before transforming into a parasitic adult which migrate downstream to the ocean or lake (Scott and Crossman 1973, Beamish and Levings 1991). Downstream migration is often initiated by an increase in discharge (Beamish and Levings 1991). In BC, lake-dwelling Pacific lamprey are known to be predators on fish in many lakes (Carl 1953, Coots 1955, Pletcher 1963).

Ocean residency of adults lasts between 12 - 20 months before Pacific lamprey return to the stream to spawn (Scott and Crossman 1973). Adults parasitize adult salmon (Birman 1950, Williams and Gilhousen 1968), and whales off the BC coast (Pike 1951). The average length of life after metamorphosis from an ammocoete to adult is approximately two-and-a-half years for Pacific lamprey (Beamish and Levings 1991). Total life span may last up to seven years, and they may reach up to 54 cm in length (Scott and Crossman 1973).

STURGEONS (ACIPENSERIDAE)

GREEN STURGEON (*ACIPENSER MEDIROSTRIS*)

British Columbia is the only province in Canada where green sturgeon are found. Recently, COSEWIC listed green sturgeon as a vulnerable species in Canada (Campbell 1998), and in BC the CDC listed it as endangered or threatened (Red listed) (CDC 2000). They inhabit brackish waters along the entire coast of BC, including Vancouver Island (Scott and Crossman 1973) and Queen Charlotte Islands (Slack and Stace-Smith 1996). This species is rare in freshwater (Scott and Crossman 1973, Haas 1998), and is infrequently seen in the lower Fraser, Skeena, Nass, Stikine and Taku Rivers (McPhail and Carveth 1993a). In the rest of North America, green sturgeon are found in coastal waters from the Gulf of Alaska to San Francisco Bay, California (Scott and Crossman 1973) and south to Baja, California (Morrow 1980). Green sturgeon are more abundant in Korea, China, northern Japan, and Russia to the Amur River then they are in North America (Scott and Crossman 1973).

There is very little habitat information available for green sturgeon. Their capture in salmon nets in the lower Fraser River during late summer and fall suggests they are an anadromous species (Scott and Crossman 1973). Spawning is assumed to occur during late June and July, however these records come from Asian populations (Scott and Crossman 1973).

WHITE STURGEON (*ACIPENSER TRANSMONTANUS*)

White sturgeon inhabit coastal and inland rivers and lakes in BC. They are most common in the Fraser River and some of its major tributaries including the Harrison, Lower Pitt, Nechako, Stuart and Stellako rivers (Scott and Crossman 1973, Cannings and Ptolemy 1998). White sturgeon are also found in the Columbia and Kootenay rivers (Cannings and Ptolemy 1998). The population living in and upstream of Kootenay Lake is landlocked (Northcote 1973). This population is isolated from other Columbia River populations by the Bonnington Falls. Since 1994, this population has been Red listed in BC (R.L. & L. Environmental Services Ltd. 1999, CDC 2000), and listed as endangered under the United States Endangered Species Act (U.S. Fish and Wildlife Service 1999). White sturgeon from the main Columbia River, the Nechako and Fraser rivers are also Red listed in BC (CDC 2000).

Some of the major lakes that support white sturgeon are Takla, Fraser, Trembleur, Stuart, Kootenay, Arrow, Slocan, Duncan, Harrison and Williams lakes (Cannings and Ptolemy 1998). On Vancouver Island, white sturgeon has been reported in Duncan Lake (Scott and Crossman 1973). Outside BC, white sturgeon are found in coastal systems from the Aleutian Islands to Monterey, California (Scott and Crossman 1973). This species will sometimes venture into salt water, but is not anadromous (Lane 1991). White sturgeon move into sloughs and side channels of large rivers like the Fraser River during summer in response to changes in temperature (Lane 1991).

The actual location and habitat use of white sturgeon in lakes is largely unknown. In Kootenay Lake, non-spawning white sturgeon inhabit bays and deltas including Crawford Bay, Duncan Delta and Creston Delta (R.L. & L. Environmental Services Ltd. 1999). During the fall, many white sturgeon were found in Duncan Delta (the northern inlet of the lake), but in all other seasons, they were most common at the southern inlet of the lake (Creston Delta). Their distribution within the lake is most likely related to food availability. Kokanee salmon, a major food source for white sturgeon, spawn during the fall in Duncan Delta. White sturgeon can be found between 10 - 100 m of water in Kootenay Lake during the winter (Cannings and Ptolemy 1998), and 3 - 40 m during the fall (R.L. & L. Environmental Services Ltd. 1998). During the spring white sturgeon have been observed basking near the surface in Williams, Trembleur and Harrison Lakes (Cannings and Ptolemy 1998). In general, it seems that white sturgeon are found near inlet and outlet rivers and creeks. For example, in the Upper Arrow Lake, white sturgeon are found near Incomappleux River, a major inlet to the lake (Cannings and Ptolemy 1998). In Harrison Lake, white sturgeon were caught in water 120 m deep, 40 m from the surface (J. Hume, Fisheries and Oceans Canada, 4222 Columbia Valley Highway, Cultus Lake, BC, V2R 5B6 personal communication.). Most research on white sturgeon in the past 10 years has focussed on their distribution and spawning habitat in major rivers such as the Fraser and Columbia Rivers.

Spawning occurs in rivers during peak flows from May through July and August (Cannings and Ptolemy 1998, Perrin et al. 1999). Perrin et al. (1999), described spawning sites within the Fraser River as being in large eddies or areas with laminar flow without upwelling. Spawning in the Columbia River takes place in swift flowing water (0.5-2.9 m/s), at depths ranging between 0.5 - 6.5 m, at water temperatures between 10-18°C, (Parsely et al. 1993, Perrin et al. 1999). In the Sacramento River, spawning occurs when water temperatures are at 7.8°C (Kohlhorst 1976). Eggs are adhesive (Monoco and Doroshov 1983) and are probably broadcast (Lane 1991) over coarse substrate, such as gravel, cobble, boulder, bedrock, sand and silt substrates (Parsley et al. 1993, Perrin et al. 1999). In the Kootenay River, white sturgeon make pre-spawning migrations upstream from Kootenay Lake to spawning grounds (R.L.& L. Environmental Services Ltd. 1999). Males and female white sturgeon migrate back downstream after spawning in the Kootenay River. These pre- and post-spawning migrations can be as long as 200 km in distance.

Larval sturgeon were found in the main channel and side channels of the lower Fraser River shortly after spawning (Perrin et al. 1999). Larvae were found in areas with a current velocity of 0.7-2.1 m/s, at average depths of 0.5 - 3.3 m but as deep as 10 m and water temperatures of 14.8-18.4°C. Young-of-the-year white sturgeon from the Columbia River, were observed at depths > 9 m and velocities between 0.2 - 0.7 m/s (Parsely et al. 1993). Substrate used by young-of-the-year was primarily sand, but hard clay, mud/silt, cobble, gravel, and sometimes boulder substrate were also used. Juvenile white sturgeon from the Columbia River were observed at depths > 4 m and velocities < 1.3 m/s.

Female white sturgeon mature much later than males. In California, males reach sexual maturity at age nine and females at age 13 - 16 (Wydoski and Whitney 1979). In the lower Fraser River, the age of first spawning for females ranges between 11 - 34 years, while for males the range is 11 - 24 years (Semakula and Larkin 1968). Males spawn on average every two to five years, while females spawn every three to eight years (Semakula and Larkin 1968). White sturgeon can live over 100 years and reach 6 m in length (Cannings and Ptolemy 1998).

MOONEYES (*HIODONTIDAE*)

GOLDEYE (*HIODON ALOSOIDES*)

Goldeye have a disjunct distribution across Canada. There are two fairly isolated ranges, one being in the Liard drainage of north-eastern BC (McPhail and Lindsey 1970) and the other being near the Quebec-Ontario border (Scott and Crossman 1973). The larger distribution ranges from west of the Great Lakes, to the eastern slopes of the Rocky Mountains in BC, and from Great Bear Lake in the north, south to the Mississippi River (Battle and Sprules 1960, Scott and Crossman 1973). Goldeye are common in large muddy, clay dominated rivers (McPhail and Lindsey 1970, Brown and Coon 1994), or in small lakes, ponds and marshes (Scott and Crossman 1973).

Goldeye begin spawning in the spring (May) after surface ice break-up and extends until early July (Battle and Sprules 1960). Spawning takes place on shallow nearshore areas (Battle and Sprules 1960) and in rivers (Scott and Crossman 1973). Eggs of goldeye are semi-buoyant (Battle and Sprules 1960).

Males mature one year earlier than females, which can range between two to ten years of age depending on latitude (Battle and Sprules 1960). Northern populations, such as in Lake Claire, Alberta will mature between six to nine years, while more southern populations mature between two to three years (Battle and Sprules 1960). Females may spawn every year after becoming sexually mature (Kennedy and Sprules 1967). In large lakes, such as Lake Athabasca and Great Slave Lake, goldeye are found near the surface, where they feed on invertebrates and sometimes fish (McPhail and Lindsey 1970). Juvenile and adult goldeye in Great Slave Lake, NWT were found in shallow water (< 5 m deep) near river inflows (Rawson 1951). Goldeye overwinter in deeper waters of lakes and rivers (Scott and Crossman 1973).

HERRINGS (*CLUPEIDAE*)

AMERICAN SHAD (*ALOSA SAPIDISSIMA*)

American shad is an Atlantic coast species, that is not abundant in Canada off the coast of Newfoundland and Labrador (Dempson et al. 1983). It was introduced to the Sacramento River, California in 1871 and has spread north since that time (Scott and Crossman 1973). It is now found from the Kamchatka Peninsula in Asia, to Todos Santos Bay, Mexico (Page and Burr 1991). American shad were first caught in BC in 1876, and are frequently caught in the Fraser River (Clemens and Wilby 1961). Most information for this species comes from research done on Atlantic populations, which is summarized by Bradbury et al. (1999).

American shad are anadromous (Scott and Crossman 1973). Movement into spawning streams begins in late April and late June (Bradbury et al. 1999) when water temperatures reach at least 4°C (Leggett 1976). Spawning only takes place in rivers or brackish water and never in lakes (Leim and Scott 1966, Scott and Crossman 1973, Scott and Scott 1988). Spawning begins in May or June and will continue to July (Leim and Scott 1966, Scott and Scott 1988). Water temperature during spawning ranges between 13 - 20°C (Scott and Scott 1988). Spawning takes place in areas with moderate to strong currents (Marcy 1972, Scott and Scott 1988, Ross et al. 1993), where the substrate is free of silt accumulation (Bradbury et al.

1999). Eggs are emitted into the water column over a mix of sand, gravel, boulder, silt and muck substrates (Leggett 1976, Morrow 1980), in water 0.2 - 12 m in depth (Bradbury et al. 1999, Ross et al. 1993). The critical factor during spawning is that the eggs need to be laid far enough upstream to allow them to drift and hatch before reaching saltwater (Bradbury et al. 1999).

The eggs are heavier than water, so eventually sink to the bottom during their journey downstream (Scott and Crossman 1973, Morrow 1980, Scott and Scott 1988). The eggs hatch within eight to twelve days at temperatures between 11 - 15°C (Bradbury et al. 1999). Larvae are planktonic and remain in this form for four to five weeks, before metamorphosing into the juvenile form (Bradbury et al. 1999). Juveniles continue to move downstream towards brackish water (Leim and Scott 1966). When water temperatures fall below 15°C during the fall, all juvenile American shad have moved into salt water (Scott and Crossman 1973, Morrow 1980). Some will remain in the estuary for another year, while others move directly to the open ocean (Bradbury et al. 1999).

Post-spawning migration back to the ocean is immediate (Leim and Scott 1966, Scott and Crossman 1973, Leggett 1976, Morrow 1980), or is delayed until October or November (Scott and Scott 1988). Atlantic populations of American shad have a distinct and extensive ocean migration pattern (Dempson et al. 1983). They migrate northward during the summer, some to northern Labrador, and return southward during the winter to overwinter in the southern portion of their range. By undertaking this north then south migrational pattern, American shad remain within their preferred temperature range 13 - 18°C (Bradbury et al. 1999), that corresponds with the temperature of the ocean isotherm. Others suggest that American shad prefer water temperatures between 2 - 15°C (Neves and Depres 1979). On the Atlantic coast, American shad will spend two to six years in the ocean before returning to spawn (Leggett 1976, Leggett and Carscadden 1978, Morrow 1980, Melvin et al. 1986). It is suggested that there is a latitudinal gradient in the occurrence of repeat spawning, with more northern populations spawning more times than southern populations (Leggett and Carscaddem 1978). American shad in Canada may live up to 13 years, and spawn up to seven times (Bradbury et al. 1999).

CARPS AND MINNOWS (*CYPRINIDAE*)

CHISELMOUTH (*ACROCHEILUS ALUTACEUS*)

Chiselmouth have a limited distribution in BC. They have been Blue listed by the CDC in BC (CDC 2000). They typically inhabit large, relatively productive lakes (G. Haas, BC Fisheries, 2204 Main Mall, Vancouver, BC, V6T 1Z4, personal communication.), such as Osoyoos, Missezula, Wolfe, Skaha, Galagher, Tugulnuit, Maram, Windermere and possibly Nicola lakes of the Fraser and Columbia River drainages (Scott and Crossman 1973, Cannings and Ptolemy 1998). However, their occurrence within lakes increases as one moves south into the United States (G. Haas, BC Fisheries, 2204 Main Mall, Vancouver, BC, V6T 1Z4, personal communication.), where they are found in Oregon, Washington, Nevada and Idaho (Scott and Crossman 1973). More often in BC, chiselmouth are found in streams and rivers including Wolfe Creek, Nazko, Euchiniko, Kettle and Okanagan rivers. Chislemouth in streams prefer warm areas (> 20°C) of moderate to fast current (Wydoski and Whitney 1979, Rosenfeld et al. 2000b). Temperature may be what determines chiselmouth distribution within drainages (Rosenfeld et al. 2000b). Rosenfeld et al. (2000b) found that chiselmouth were never present in rivers < 17 m wide in the Blackwater River drainage, BC.

Chiselmouth spawn in streams, possibly over open bottom or boulder substrates, however little is known about their spawning behaviours (Scott and Crossman 1973). Spawning is assumed to take place during spring, beginning in June (Moodie 1966). Young-of-the-year and juvenile chiselmouth rear in shallow (< 1 m), vegetated, slow flowing backwaters and river margins (Rosenfeld et al. 1998, Rosenfeld et al. 2000b). Often young-of-the-year and juveniles form schools with other species of cyprinids. In rivers, adult chiselmouth are found in deep (> 1 m), fast flowing water over cobble and boulder substrate, presumably because they feed on algae that grows on the substrate. Rosenfeld et al. (2000b) suggested that adult chiselmouth migrate to lakes from rivers to overwinter. In lakes, chiselmouth probably inhabit shallow, littoral areas over coarse substrates similar to that in streams (G. Haas, BC Fisheries, 2204 Main Mall, Vancouver, BC, V6T 1Z4, personal communication.). Sexual maturity is probably at three to four years of age (Cannings and Ptolemy 1998). Maximum age is thought to be around six years.

GOLDFISH (*CARASSIUS AURATUS*)

Goldfish are native to eastern Asia and China, but have been introduced to most parts of the world (Scott and Crossman 1973). As early as 960 in the Sung Dynasty (Hervey and Hems 1968), goldfish have been kept as pets. Goldfish farms were established in Maryland in the late 1800s (Scott and Crossman 1973). Since then, goldfish have established themselves throughout the United States, and occur sporadically in Canada. In 1973, Scott and Crossman reported that goldfish in BC were only known from a large pond in Salmon Arm and a small lake near Kamloops. Now, goldfish are found throughout the lower Fraser River, the south coast areas, in the Kootenay drainage and Vancouver Island (BC Fisheries 2000a). Goldfish are found in warm, muddy, turbid water of rivers, ponds and lakes most often associated with vegetation in shallow areas (Scott and Crossman 1973, Page and Burr 1991).

Spawning takes place during spring between May and June in shallow weedy areas (Scott and Crossman 1973). Eggs are adhesive and are laid during the day over submerged aquatic vegetation of willow roots. Females often mate with more than one male during spawning. Eggs incubate for three to four days when water temperature is between 18.5 - 29.5°C, but eggs can hatch within 64 - 72 hours if water temperatures are between 24 - 28°C (Battle 1940).

LAKE CHUB (*COUESIUS PLUMBEUS*)

The lake chub is found throughout BC, in the Fraser, Columbia, Liard, Skeena, Peace, Yukon and Mackenzie river drainages (McAllister 1961, Scott and Crossman 1973). However, they are not present along the coast or on the islands in BC (Scott and Crossman 1973). Their range extends from the Yukon River in Alaska, to the Mackenzie delta, south through Alberta, Saskatchewan, and Manitoba, to Nova Scotia (McAllister 1961, McPhail and Lindsey 1970, Scott and Crossman 1973). In the United States, scattered populations of lake chub can be found in New England, New York, Michigan, Wisconsin, Minnesota, across to Colorado and Idaho (Scott and Crossman 1973, Morrow 1980). Lake chub prefer lake habitat, but are also found in clear and murky streams and rivers (McAllister 1961, McPhail and Lindsey 1970, Scott and Crossman 1973).

Because of the wide distribution of this species, timing of spawning may occur at different times in different locations. However there is little information on this subject. Spawning has been recorded in mid-May in Saskatchewan, late-May early-June in BC (McPhail and Lindsey 1970), August in the NWT (Richardson 1935) and, April (Scott and Crossman 1973) and June in Ontario (Dymond 1926). Lake chub migrate from lakes into tributary streams to spawn over gravel or over and underneath large rocks in shallow water (McPhail and Lindsey 1970, Morrow 1980). In lakes, spawning usually takes place in shallow shores over rocky substrates, but spawning over silt, leaves, gravel, cobble and boulder has been observed (Brown et al. 1970). Males do not built nests or protect eggs (Brown et al. 1970, Scott and Crossman 1973). Life expectancy of lake chub is rarely beyond five years of age, with sexual maturity occurring at ages three to four (McPhail and Lindsey 1970).

Typically, lake chub are a shallow water, bottom dwelling species (McPhail and Lindsey 1970, Emery 1973, Becker 1983). They are often found over primarily sandy bottoms that have some interspersed boulders (Becker 1983). Lake chub are known to inhabit deeper waters, usually during thermal stratification in summer (Scott and Crossman 1973, Burgess 1978, Morrow 1980). Emery (1973) found that during the day lake chub moved to waters deeper than 10 m. In Ontario lakes at night, lake chub were found at highest abundance between 5 - 8 m of water, but were also found between 2 - 30 m (Emery 1973). Large lake chub at depths of 18 - 25 m were within 0.1 - 0.5 m of the bottom (Emery 1973).

COMMON CARP (*CYPRINUS CARPIO*)

Carp first appeared in Okanagan Lake, BC in 1917 (Clemens et al. 1939). They were thought to have come from carp that were introduced into Washington State in 1882 (Carl et al. 1967). By 1946, carp had moved down the Fraser River valley to Vancouver (Carl et al. 1967). As reported by Carl et al. (1967), carp were present to the north Thompson River at Little Fort and Kamloops. In the early 1900s, carp were also introduced to a pond on Vancouver Island. Presently, carp are found elsewhere on Vancouver Island, and the Fraser and Columbia River drainages (BC Fisheries 2000a). Carp are native to temperate areas in Asia, such as China, but are now found across Europe and North America (Carl et al. 1967). Carp inhabit a variety of habitats including lakes and large rivers (Brown and Coon 1994), and utilize bottom habitat (Clemens et al. 1939).

Spawning is initiated by warming water temperatures during spring and early summer (Scott and Crossman 1973). Carp move into weedy (submergent and emergent vegetation), shallow areas with mucky bottoms (Swee and McCrimmon 1966, G. Haas, BC Fisheries, 2204 Main Mall, Vancouver, BC, V6T 1Z4, personal communication.). They form large groups that congregate near the surface (Scott and Crossman 1973). As water temperatures reach 17°C, smaller groups of one to three females and up to 15 males form and begin to spawn (McCrimmon 1968, Scott and Crossman 1973). Spawning ceases once water temperatures reach 28°C (Swee and McCrimmon 1966, McCrimmon 1968). The adhesive eggs are emitted into the water, and settle on weeds, grasses and roots (McCrimmon 1968). Eggs will hatch within three to six days depending on water temperature (Swee and McCrimmon 1966). Young-of-the-year have been caught within the shallow regions of Lake St. Lawrence up to two weeks after hatching, although after that time it was difficult to locate them (Swee and McCrimmon 1966). Adults stay within 3 m of water during the late summer and fall, and only move to deeper water during the winter when shallow areas freeze through (Swee and McCrimmon 1966). Males reach sexual maturity at ages three to four, and females between ages four to five (McCrimmon 1968). Individuals can reach over 20 years of age in North America (McCrimmon 1968). Upper lethal temperature limit is 31 - 34°C (Black 1953).

BRASSY MINNOW (*HYBOGNATHUS HANKINSONI*)

The distribution of brassy minnow within BC is fragmented. They are found in the lower Fraser River valley in areas such as the Chilliwack Gravel Slough, Sumas, Brunette, Stave, and Salmon rivers, and Hatzic, Burnaby and Deer lakes (Cannings and Ptolemy 1998). Brassy minnow also occur near Horsefly on the Cariboo Plateau in Wright, Hoodoo, Dogs, Merton creeks, the Horsefly River, Shelley Slough, and Bear, Esker, Huble and Summit lakes. There are a few unconfirmed reports that brassy minnow are present in the Peace River drainage. It is believed that brassy minnow have disappeared from many locations from central BC. As a result, they are Blue listed in BC (CDC 2000). Brassy minnow inhabit primarily small, slow flowing weedy creeks, cool, acidic, boggy streams and small, shallow lakes (Dymond 1939, McPhail and Lindsey 1970, Cannings and Ptolemy 1998). Often they are present over sand, gravel or mud with organic material present (Cannings and Ptolemy 1998). Brassy minnows form schools and may be found swimming off the bottom within the limnetic zone in shallow water (G. Haas, BC Fisheries, 2204 Main Mall, Vancouver, BC, V6T 1Z4, personal communication.).

Spawning takes place during May or June (Scott and Crossman 1973). Brassy minnow spawn during the spring in shallow areas depositing their eggs near or on vegetation (Dobie et al. 1956, Becker 1983).

Spawning is usually initiated when water temperatures reach between 10 - 12.8°C (Dobie et al. 1956). Sexual maturity is at one to two years of age.

PEARL DACE (*MARGARISCUS MARGARITAI*)

In BC, pearl dace Blue listed (CDC 2000). They are only found in two or three locations. They inhabit Lattice Creek, a tributary of the Redwillow River in the Kiskatinaw Plateau of north-eastern BC (Cannings and Ptolemy 1998, Haas 1998), and Tsinhia Lake (Cannings and Ptolemy 1998). They once inhabited Charlie Lake, BC (Cannings 1993), but may have been eliminated from this lake due to the introduction of piscivorous fish (Cannings and Ptolemy 1998), although Haas (1998) does not report this extirpation. Pearl dace are thought to hybridize with lake chub, northern redbelly dace and finescale dace (Wells 1981, Nelson and Paetz 1992, McPhail and Carveth 1993b). It has been suggested that there may not be any "pure" populations of peal dace in BC (McPhail and Carveth 1993b). The designation of a subspecies, the northern pearl dace (*Semotilus margarita nachtriebi*), that is unique to Canada inhabiting waters from the Maritimes to BC, has been proposed (Scott and Crossman 1973).

Depending on the general location, pearl dace prefer different types of habitats. In BC, pearl dace are more common in slow flowing, tea coloured creeks (Cannings and Ptolemy 1998). In northern locations, pearl dace are found in bog drainage systems, small lakes and ponds (Bendell and McNicol 1987), while in more southern locations, they are found in clean, cool headwater streams (McPhail and Lindsey 1970, Scott and Crossman 1973). Elsewhere they are found in peaty waters and beaver ponds (Scott and Crossman 1973). In Ontario, pearl dace inhabit small lakes (Bendell and McNicol 1987), at deeper depths to stay at temperatures < 20°C (Tallman et al. 1984). In BC lakes, pearl dace are most likely found in shallow water over a variety of substrate types (G. Haas, BC Fisheries, 2204 Main Mall, Vancouver, BC, V6T 1Z4, personal communication.). Pearl dace feed on invertebrates, plankton and filamentous algae (Scott and Crossman 1973, Tallman and Gee 1982).

In lakes, pearl dace spawn in tributary streams or in vegetation along the edges of the lake during spring just after ice-melt (Tallman et al. 1984). In beaver ponds and small lakes, spawning is over organic material (Bendell and McNicol 1987). In streams, pearl dace spawn in water around 0.6 m deep over sand or gravel (McPhail and Lindsey 1970), or hard substrates (Langlois 1929). Males do not build nests, but defend small territories around the spawning sites (Langlois 1929). Sexual maturity is at age two (Becker 1983). Females may live to four years of age, while males only reach three years (Nelson and Paetz 1992).

PEAMOUTH CHUB (*MYLOCHEILUS CAURINUS*)

Peamouth chub are found in lakes and rivers of BC from the Peace, Nass, Skeena, Fraser and Columbia rivers (Scott and Crossman 1973). This species is found in a few lakes on the west coast and southern portion of Vancouver Island (Holden, Fishhook, Kennedy and Cecilia lakes, Scott and Crossman 1973). Peamouth chub are also known from a lake on Bowen Island and Nelson Island in Jervis Inlet (Scott and Crossman 1973). Peamouth chub are one of the only cyprinids that are able to withstand saline water, and have been documented in brackish water off Spanish Banks (Scott and Crossman 1973). Typically, peamouth chub form small schools and inhabit shallow, vegetated waters of lakes and rivers (Clemens et al. 1939, Ricker 1952, Godfrey 1955, Narver 1967, Scott and Crossman 1973, Beauchamp et al. 1995, Porter and Rosenfeld 1999).

Spawning in BC has been recorded in May or June (Brett and Pritchard 1946a, Carl et al. 1967). Peamouth chub spawn in groups, usually consisting of several males and one female, although these groups can include up to several hundred individuals (Schultz 1935). Spawning takes place over stony, rubble substrate in shallow nearshore areas of lakes, when water temperatures reach 12°C (Schultz 1935).

Ripe peamouth chub have been found in streams, but there is no concrete evidence that they spawn in streams (Carl et al. 1967). Brett and Pritchard (1946a) did note that peamouth chub move into small streams off Lakesle Lake, BC during the spawning season and then return to the lake afterwards. The adhesive eggs are emitted into the water and adhere to the coarse substrate (Schultz 1935). Young-of-the-year peamouth chub remain in shallow nearshore areas until the end of their first summer, when they move into deeper water (Carl et al. 1967).

Peamouth chub are bottom feeders (Scott and Crossman 1973). In BC, they have been found in shallow areas of Cultus Lake (Ricker 1952), and between depths of 0 - 15 m but most commonly < 5 m in Lakelse Lake (Godfrey 1955), and < 7 m deep in Chub Lake (Narver 1967). Scarsbrook and McDonald (1973, 1975) caught a small number of peamouth chub in the limnetic zone of Babine Lake, BC. Beauchamp et al. (1995) described peamouth chub in Lake Ozette, Washington as a profundal-littoral species, associated with the bottom primarily in ≤ 15 m, but also common at > 15 m deep. In the Nazko River, BC, juvenile peamouth chub preferred slow flowing backwaters, 0.25 - 0.5 m deep, near gravel substrate and vegetation (Porter and Rosenfeld 1999). Upper lethal temperature was recorded to be 27°C by Black (1953). Peamouth chub can live up to seven years of age (Clemens 1939).

EMERALD SHINER (*NOTROPIS ATHERINDOIDES*)

Emerald shiner are only found in the Fort Nelson River at Old Fort Nelson, BC, although this species may be more widespread in the Liard and Nelson river drainages (Cannings and Ptolemy 1998). Elsewhere they are widespread from tributaries in the southern parts of the Mackenzie River, to the St. Lawrence River and the Great Lakes, south to the Mississippi valley, Gulf coast in Alabama and the Trinity River, Texas (Scott and Crossman 1973). In BC, emerald shiners are Red listed (CDC 2000). Emerald shiners are found in large, open lakes and rivers (Scott and Crossman 1973), or at the mouths of smaller streams (Cannings and Ptolemy 1998). Emerald shiners are found in a section of Fort Nelson River that is 2 - 10 m wide, muddy bottomed, with tea-coloured water (Cannings and Ptolemy 1998). In general, emerald shiner are primarily limnetic fish that form large schools (Fuchs 1967, Scott and Crossman 1973). During the summer these schools stay in offshore areas near the surface of the water, but during the fall they move inshore often under piers, docks and near river mouths (Scott and Crossman 1973). This species moves into deeper offshore water during the winter. During the spring they inhabit surface waters during the day and deep water at night.

Emerald shiners spawn in late spring and summer (Scott and Crossman 1973), from July to late-August (Dymon 1926, Fish 1932, Langlois 1954). They are thought to spawn in midwater (Scott and Crossman 1973), offshore at depths of 2 - 6 m over clean substrate (Becker 1983). Eggs fall to the bottom and hatch within 32 hours, at 24°C (Flittner 1964, Scott and Crossman 1973). Young-of-the-year form large schools that congregate in nearshore areas in water < 10 m deep (Fuchs 1967, Scott and Crossman 1973). Growth is very high during their first growing season (Fuchs 1967). In the fall, the young-of-the-year can be found in highest numbers over sandy beaches or in sheltered bays (Fuchs 1967). Emerald shiners do not seem to live past three years of age (McCrimmon 1956, Fuchs 1967).

SPOTTAIL SHINER (*NOTROPIS HUDSONIUS*)

The spottail shiners are present only in the far north-eastern corner of BC, primarily in Maxhamish Lake (Cannings and Ptolemy 1998). They were introduced to Charlie Lake in 1986 and spottail shiners have been collected in the Beatton River since 1983 and the Peace River since 1989 (BC Fisheries 2000a). Spottail shiners occur across North America, from the Mackenzie River to the St. Lawrence River in Quebec, south to Georgia, Iowa and Missouri (Scott and Crossman 1973). Because of their limited distribution in BC, spottail shiners are Red listed (CDC 2000). Spottail shiners are most commonly found in large lakes and rivers. They are often the most abundant minnow caught in northern lakes. In lakes, spottail shiners are found in shallow areas with moderate amounts of vegetation over sand and rocks (McCann 1959, Cannings and Ptolemy 1998). In Maxhamish Lake, BC, spottail shiners are found along the south shore and near the mouth of an inlet stream (Cannings and Ptolemy 1998).

Spawning takes place during spring and early summer depending on latitude and temperature (Scott and Crossman 1973, Becker 1983). More northern populations spawn later in the year (July), while in southern lakes, spawning takes place during May (McCann 1959, Smith and Kramer 1964, Peer 1966). Spawning occurs over sandy shoals in June and July in Canada (Peer 1966, Scott and Crossman 1973). Adults leave the shoals after spawning and move into water 4 - 7 m in depth (Peer 1966). Eggs hatch within about a month, and young-of-the-year may remain on the shoals (Peer 1966). Smith and Kramer (1964) collected young-of-the-year and juvenile spottail shiners on the bottom and within the water column in <7-m of water. Sexually maturity is after one to four years, once a minimum total length of 72 mm is reached (Peer 1966). Total life span is between four to five years (McCann 1959, Smith and Kramer 1964).

NORTHERN REDBELLY DACE (*PHOXINUS EOS*)

Northern redbelly dace are only found in the northeast edge of BC and were reported in Charlie Lake by McPhail and Lindsey (1970). The BC location signifies the most westerly point in the overall distribution of northern redbelly dace. Their range extends from the Peace River, Alberta to Nova Scotia, south to New York and north to Fuller Lake, NWT (McPhail and Lindsey 1970). Normally this species is found in quiet, warm waters of boggy ponds, small lakes and pools within creeks that have primarily silt and detritus bottoms (Scott and Crossman 1973). Often water in these types of habitats is dark and slightly acidic. Northern redbelly dace feed on filamentous algae and other vegetation (McPhail and Lindsey 1970). This species hybridizes with finescale dace (Hubbs and Brown 1929, New 1962, Legendre 1969, Das and Nelson 1989), and hybrid populations are known to exist in Graveyard Creek and Tsinhis Lake, BC (Cannings and Ptolemy 1998). The hybrid populations are Red listed in BC (CDC 2000). It was suggested that there are no "pure" populations of northern redbelly dace in BC (McPhail and Carveth 1993b). There is also documented evidence of morphological variation among populations in three different Ontario watersheds (Toline and Baker 1993).

Northern redbelly dace spawn in spring and early summer, depending on latitude, usually with more northern populations spawning later (Scott and Crossman 1973). In Alberta, northern redbelly dace spawn in mid-June and late July when temperatures range between 13 - 18°C (Das and Nelson 1990). Some females in more southern populations will spawn more than once during a season thereby extending the spawning season to late August (Hubbs and Cooper 1936, Powles et al. 1992). Cooper (1935) observed spawning activity in May and August in Michigan, while McPhail and Lindsey (1970) reported spawning in late August in northern Alberta. Females deposit nonadhesive eggs over and within filamentous algae with one or more males (Cooper 1935, Hubbs and Cooper 1936). Eggs hatch within eight to ten days (Cooper 1935) at temperatures between 21 - 26.7°C (Hubbs and Cooper 1936).

Sexual maturity depends on the time at which fish hatch. Individuals hatched in early summer spawn the next summer, but individuals hatched during late summer spawn after two summers (Hubbs and Cooper 1936). The oldest male was recorded to be six years of age, and the oldest female was eight years of age (Scott and Crossman 1973). Average life span is around three years (Cooper 1935).

FINESCALE DACE (*PHOXINUS NEOGAEUS*)

In BC, finescale dace are found in the Mackenzie River drainage in the Fort Nelson River and One Island Lake (Scott and Crossman 1973). Typically finescale dace inhabit boggy ponds, lakes and pools in streams over silt and near vegetation (Scott and Crossman 1973, Page and Burr 1991). This species hybridizes with northern redbelly dace (Hubbs and Brown 1929, New 1962, Legendre 1969, Das and Nelson 1989), and hybrid populations are known to exist in Graveyard Creek and Tsinhis Lake, BC (Cannings and Ptolemy 1998).

Spawning in Wisconsin was observed during April to June (Becker 1983). In Alberta, finescale dace spawn in mid-June and late July when temperatures ranged between 13 - 18°C (Das and Nelson 1990).

FATHEAD MINNOW (*PIMEPHALES PROMELAS*)

Fathead minnow are introduced into BC. The native range of fathead minnow is south of Great Slave Lake, NWT, south to Mexico, and east to New Brunswick (McPhail and Lindsey 1970). Fathead minnow are native to the Peace River, but not extending into BC. Now fathead minnow are present on the BC portion of the Peace River, on Vancouver Island, and the lower mainland, including the lower Fraser River (G. Haas, BC Fisheries, 2204 Main Mall, Vancouver, BC, V6T 1Z4, personal communication.). Typically, fathead minnow prefer still, muddy waters in ponds and small lakes (Bendell and McNicol 1987). They are also found in muddy rivers and ditches (McPhail and Lindsey 1970, Scott and Crossman 1973), clear, acidic beaver ponds (Dymond 1926, Dymond and Scott 1941), and saline lakes (Rawson and Moore 1944, Nelson 1968a). The fathead minnow is thought to be adaptable to quickly changing environmental conditions, but has limited competitive abilities (Cross 1967).

Spawning activities start when water temperatures reach 15.6°C or 17.8°C (Dobie et al. 1956, Scott and Crossman 1973) during May to August (Dymond 1926, Markus 1934, Richardson 1937, Toner 1943, Scott and Crossman 1973). Nests are selected under rocks, lily pads, branches or logs in water < 1 m deep by males (Wynne-Edwards 1932, Markus 1934, Richardson 1937). Males attract females to the nest (Richardson 1937) where the females deposit the adhesive eggs under the surface of the log or rock (Wynne-Edwards 1932, Markus 1934). Males fertilize the eggs and the females are driven away from the nest (Richardson 1937). Males will mate with more than one female, and females will deposit eggs in more than one nest in a single breeding season (Wynne-Edwards 1932). Eggs hatch within five days at 25°C (Scott and Crossman 1973). Sexual maturity is generally not until two years, but individuals in southern areas have been observed spawning within their first year of life (Markus 1934). Individuals often do not live past two years of age, and often die after spawning (Markus 1934), although this has not been studied for Canadian populations. It is thought, due to colder water temperature in Canada, fathead minnow may live up to three years (Scott and Crossman 1973).

FLATHEAD CHUB (*PLATYGOBIO GRACILIS*)

In BC, the flathead chub occurs in the Peace River system. Carl et al. (1967) reported samples from Lynx Creek east of Hudson Hope, and the Fort Nelson and Muskwa rivers. Elsewhere in Canada, flathead chub are found from the Mackenzie River in the NWT to Lake Winnipeg in Manitoba, south to the Mississippi and Rio Grande rivers (McAllister 1961, Scott and Crossman 1973). Flathead chub inhabit muddy, turbid, flowing main channel rivers (McAllister 1961, Olund and Cross 1961), but move into smaller streams to spawn (Olund and Cross 1961, Scott and Crossman 1973). They are seldom found in the clear, still waters of lakes or ponds (Olund and Cross 1961, Scott and Crossman 1973).

Spawning takes place in summer, when water levels are at their lowest (Olund and Cross 1961). Ripe flathead chub have been collected in August in the Milk River, June in the Saskatchewan River, and June in the Red Deer River (Olund and Cross 1961). Spent individuals have been captured in the Mackenzie River in June, and August in the Peace River (McPhail and Lindsey 1970). Sexual maturity is attained at a size of 8.5 cm (Olund and Cross 1961), with maximum size being 29 - 31 cm (Scott and Crossmann 1973). Flathead chub feed on invertebrates (Scott and Crossman 1973).

NORTHERN PIKEMINNOW (*PTYCHOCHEILUS OREGONENSIS*)

In 1998 this species, previously known as the northern squawfish, was renamed the northern pikeminnow by Nelson et al. (1998). Northern pikeminnow inhabit waters of the Fraser, Columbia and Skeena river drainages in Canada and the United States (Scott and Crossman 1973). Apart from in the Peace River, where this species is found in Summit and McLeod lakes and to the townsite of Peace River in Alberta, northern pikeminnow are found west of the Continental Divide (Scott and Crossman 1973).

Northern pikeminnow prefer the still waters of lakes to flowing waters of streams (Scott and Crossman 1973). Northern pikeminnow are bottom feeders and piscivores, often found in the nearshore area of lakes (Clemens et al. 1939, Ricker 1952, Godfrey 1955, Beauchamp et al. 1995, Collis et al. 1995), and large rivers (Buchanan et al. 1981). Northern pikeminnow are thought to be a major predator and source of mortality on juvenile salmon in lakes (Rieman and Beamesderfer 1990, Tabor et al. 1993, Beauchamp et al. 1995, Collis et al. 1995, Friesen and Ward 1999). Buchanan et al. (1981) reported low levels of predation in the Willamette River, Oregon, despite large numbers of hatchery salmonids released in the river. In BC, northern pikeminnow were often observed in water ≤ 15 m deep in Cultus Lake (Ricker 1952), < 7 m in Chub Lake (Narver 1967), and < 5 m deep in Lakelse, Babine and Morrison lakes (Godfrey 1955). Adults tend to remain in deeper waters year round (Scott and Crossman 1973).

Spawning takes place during May to July over gravel substrate (Jeppson and Platts 1959, Carl et al. 1967, Patten and Rodman 1969, Scott and Crossman 1973), at temperatures between 12 - 18°C (Jeppson and Platts 1959, Beamesderfer 1992). Spawning is primarily in shallows along the lake shore, and near the mouth of tributary streams, but will occur in tributary streams when suitable habitat is not available within the lake (Jeppson and Platts 1959, Patten and Rodman 1969). In St. Joe River, Idaho, spawning took place in areas dominated by gravel and cobble substrates, in 4.9 m deep water, with bottom velocity of ≤ 0.4 m/sec (Beamesderfer 1992). A small group of one female and several males forms during spawning (Scott and Crossman 1973, Beamesderfer 1992). The sperm and adhesive eggs are broadcast into the water and settle on the gravel substrate (Jeppson and Platts 1959, Patten and Rodman 1969, Scott and Crossman 1973, Beamesderfer 1992). Eggs hatch in approximately seven to eight days (Jeppson and Platts 1959). Young-of-the-year and juvenile northern pikeminnow inhabit nearshore waters in summer (Jeppson and Platts 1959), moving to deeper offshore waters in the fall (Scott and Crossman 1973). In the St. Joe River, young-of-the-year used shallower (< 0.25 m), sandier, still water areas compared to juvenile northern pikeminnow (Beamesderfer 1992). Sexual maturity is attained at a length of 30 cm at around age six (Scott and Crossman 1973). Life expectancy of northern pikeminnow is between 15 - 20 years (McPhail and Lindsey 1970). Upper lethal temperature limit was estimated to be 29°C (Black 1953).

LONGNOSE DACE (*RHINICHTHYS CATARACTAE*)

Longnose dace occur in fast flowing streams and sometimes lakes, across North America, from the Mackenzie River drainage, south into BC, Alberta, down to Virginia, east to the Mississippi River drainage, Great Lakes, northern Manitoba, the upper St. Lawrence River, Ungava River drainages and Labrador (Scott and Crossman 1973). In BC, longnose dace are found throughout the Fraser, Columbia, Skeena and Peace river drainages. They are absent from the coastal islands and north-western corner of the province. Longnose dace inhabit clean, swift flowing, sometimes turbulent, streams usually in riffles over substrate from gravel to boulders (Gee and Machniak 1972, Scott and Crossman 1973, McPhail and Carveth 1993b). They are a benthic species (Clemens et al. 1939, Scott and Crossman 1973), although longnose dace living in Okanagan Lake have been observed in large schools swimming within the limnetic zone (G. Haas, BC Fisheries, 2204 Main Mall, Vancouver, BC, V6T 1Z4, personal communication.).

Timing of spawning is during June and early-July (McPhail and Lindsey 1970, Gee and Machniak 1972, Brazo et al. 1978), but has been observed during August in Lake Winnipeg where water temperatures were cooler than the surrounding streams (Gee and Machniak 1972). Over the majority of its range, male longnose dace build and defend redds built in gravel of riffles (Bartnik 1970, Brown et al. 1970, McPhail and Lindsey 1970, Scott and Crossman 1973, McPhail and Carveth 1993b). Longnose dace also exhibit extensive coloration and courtship behaviours during spawning which occurs during the day (McPhail and Carveth 1993b). However, in southern BC populations, spawning occurs at night, and no redd is built, or defended, and there is no ritualized courting behaviour or coloration (Bartnik 1972). Demersal, adhesive eggs are deposited among the substrate and defended by at least one parent (Bartnik 1970, 1972, McPhail and Lindsey 1970). Spawning can also occur in lakes on wave-swept shores (Brazo et al. 1978), or over boulder, cobble, and rubble substrates in shallow offshore areas (Gee and Machniak 1972).

In lakes, young-of-the-year longnose dace are limnetic, and inhabit shallow, still nearshore waters for the first four months (McPhail and Lindsey 1970, Gee and Machniak 1972, Scott and Crossman 1973). They are often associated with cover structures such as overhanging vegetation (Gee and Machniak 1972) and sand to gravel and cobble substrates (Brazo et al. 1978). They feed primarily on algae and plankton, and sometimes fish (Brazo et al. 1978, Edwards et al. 1983). Once at a size of 30 mm total length, young-of-the-year longnose dace will move to deeper waters that have swift currents (Gee and Machniak 1972). In the lower Fraser River, young-of-the-year were caught in relatively swift flowing water (Gee and Northcote 1963).

In the Nazko River drainage, juvenile longnose dace preferred slow flowing water in riffles, glides and backwaters, in water < 0.5 m deep, over gravel substrate (Porter and Rosenfeld 1999). Gee and Northcote (1963), collected juveniles in primarily slow flowing water (< 0.5 m/s) on the shallow banks (< 0.3 m) of the lower Fraser River. Adult longnose dace can be found in fast flowing (> 0.5 m/s), shallow (< 0.25 m) water in riffles, within boulder substrate (Gee and Northcote 1963, Porter and Rosenfeld 1999). Adults are thought to use the crevices of large substrate as refuge (McPhail and Lindsey 1970, Scott and Crossman 1973, Mullen and Burton 1995). Adult longnose dace also prefer areas with aquatic vegetation and overhead cover (Hubert and Rahel 1989). In lakes, adults are found over gravel and boulder substrates during the summer (Brazo et al. 1978), but will move into deeper, cooler waters when temperatures increase (Scott and Crossman 1973). Sexual maturity is at age two, although males may mature earlier than females (Bartnik 1970, McPhail and Lindsey 1970, Gibbons and Gee 1972, Brazo et al. 1978, Becker 1983). Longnose dace do not usually live past the age of four years (Brazo et al. 1978), but an individual aged at five years was caught in eastern United States (Reed and Moulton 1973).

NOOKSACK DACE (*RHINICHTHYS SP.*)

It is not certain if the Nooksack dace is a true species distinct from the longnose dace, or simply an isolated subspecies, since it does not occur with longnose dace (Cannings and Ptolemy 1998). There are genetic and morphological differences between Nooksack dace and longnose dace (McPhail 1993b, McPhail and Carveth 1993b), however further investigation is needed. The Nooksack dace has a very restricted range compared to the longnose dace. Nooksack dace are found in the Nooksack River to the Puyallup River systems along the east side of Puget Sound, and the Chehalis River on the outer coast of the Olympic Peninsula (McPhail and Lindsey 1986). In BC, this species is found in small, lowland tributaries of the Nooksack River that flow primarily through urban and agricultural areas (Cannings and Ptolemy 1998, Pearson 1998), which include Bertrand, Cave, Fishtrap, and Pepin Creeks (Inglis et al. 1992). These BC populations are isolated from United States populations by severely degraded habitat in which Nooksack dace can not inhabit (Pearson 1998). This isolation makes the BC populations vulnerable to population decline and extirpation from anthropogenic disturbances. The population from Fishtrap Creek is in poor condition due to dredging of that creek (Inglis 1995, Cannings and Ptolemy 1998, Pearson 1998). In BC, nooksack dace are Red listed (CDC 2000). Nooksack dace are often found in sympatry with cutthroat trout, coho salmon, steelhead, Salish sucker, and sticklebacks, and are a common prey item of cutthroat trout (Inglis et al. 1994).

In BC, Nooksack dace spawn at night during the spring, between April and May (McPhail 1993b). Eggs are deposited over gravel at the upstream end of riffles (McPhail 1993b). Young-of-the-year often form schools and reside in waters 10 - 20 cm deep in slow glides and the downstream end of pools over sand and mud (McPhail 1993b, 1997, Inglis et al. 1994). Often by the end of their first summer and as late as September, the schools break up (Pearson 1998). Juvenile and adult Nooksack dace associate with overhead vegetation in riffles, over gravel and cobble substrates (McPhail 1993b, Inglis et al. 1994). Nooksack dace feed at night (Pearson 1998). Sexual maturity is after one year (second summer), but they do not mate until the next spring, at age two (McPhail 1993b). Usually there are four age classes present within a population (Inglis et al. 1994), however an individual six years of age has been observed (McPhail 1997b).

LEOPARD DACE (*RHINICHTHYS FALCATUS*)

Leopard dace are only found in the Fraser and Columbia rivers east of the Cascade Mountains (Scott and Crossman 1973), in BC, Washington, Oregon and Idaho states (Haas 1998). They are known to occur in small lakes and rivers in the Fraser River as well as the Okanagan and Lower Arrow lakes, and Pend Oreille and Similkameen rivers (Scott and Crossman 1973, Peden 1991). Their distribution throughout the range is spotty (McPhail and Lindsey 1993a,b), particularly in the lower Fraser River where the population is thought to be disjunct from the rest of the range (Haas 1998). A very small number of leopard dace have been caught in Okanagan Lake and River and the Kootenay River (Peden 1991). Within the Canadian portion of the Similkameen River, usually only small juveniles are found (Peden and Hughes 1988). Adults have been captured in areas within Washington State (Peden and Hughes 1988, Peden 1991). In lakes, leopard dace inhabit stone, boulder and rubble dominated low gradient beaches that have extensive reed beds offshore (Peden 1991). They are often not found in water greater than 2 m deep, however their depth distribution in lakes needs further study (Peden 1991). Leopard dace feed on algae growing on rocks, which would explain their preference for stony areas (Peden 1991). Hydroelectric development and habitat loss from lake shore development (removing boulders and rocks to create a sandy beach) are thought to be possible causes for the spotty distribution of this species (Peden 1991, Haas 1998). Juvenile leopard dace have been found in silty, turbid wave-swept beaches of Arrow Lake (Peden 1991). Leopard dace are most often found in water with temperatures between 15 - 18°C (Peden 1991). Upper lethal temperature limit was recorded at 28°C (Black 1953).

Spawning occurs in early July (Gee and Northcote 1963). Juvenile leopard dace studied in the Nazko River drainage, BC, were found most often in shallow, slow-flowing areas associated with fine substrate, and aquatic vegetation (Porter and Rosenfeld 1999). Adult leopard dace were found in similar habitat as juveniles, but over a mixture of gravel, cobble and fine substrate and slightly faster flowing water (Porter and Rosenfeld 1999). Gee and Northcote (1963) collected young-of-the-year, juvenile and adult leopard dace in the lower Fraser River. All leopard dace were captured in shallow (< 1 m), slow flowing water (< 0.5 m/sec). Life span of leopard dace is over four years.

SPECKLED DACE (*RHINICHTHYS OSCULUS*)

Speckled dace are limited to south-central BC, in the Kettle River up to Wilkinson Creek, and Granby River a tributary of the Kettle River (Peden and Hughes 1984a, Cannings and Ptolemy 1998). Elsewhere, speckled dace are restricted to western North America in the Chehalis, Deschutes, Columbia, and Colorado rivers as well as coastal and interior streams from southern California and Mexico (Scott and Crossman 1973, Lee et al. 1980). Speckled dace are listed as a vulnerable species in Canada by COSEWIC (Campbell 1998), and a Red listed species in BC by the CDC (CDC 2000). Speckled dace inhabit a range of habitats, from cool streams and rivers to warm ephemeral streams, to desert springs and lakes (Moyle 1976, Peden and Hughes 1984a, Cannings and Ptolemy 1998). In BC, adult speckled dace have been reported in slow to moderately strong flowing streams, associated with fairly clean, uniform rock habitat (Peden and Hughes 1984a, Cannings and Ptolemy 1998). In lakes, speckled dace are active mostly at night, and least active during the winter (Cannings and Ptolemy 1998). They are bottom feeders (Cannings and Ptolemy 1998), and in the Kettle River, are found with redside shiner and northern pikeminnow which are mid-water feeders (Peden and Hughes 1980).

Spawning takes place probably during July in BC (Cannings and Ptolemy 1998). In New Mexico, speckled dace were observed spawning in early June, and during both spring and fall in Arizona (Minckley 1973). Speckled dace from lakes spawn in shallow areas over gravel, or in inlet streams at the edge of riffles (Moyle 1976). Incubation lasts six days at 18 - 19°C (Moyle 1976). Speckled dace hatched in the summer, may not mature until their second year (Peden and Hughes 1984a). Juvenile speckled dace have been found in the Kettle River over smooth stones substrate in slow to moderate currents and in the Granby River over sand substrate with some algal and vegetation (Peden and Hughes 1984a). Adults usually die soon after spawning at age two, but some live to reach age three (Peden and Hughes 1984a).

UMATILLA DACE (*RHINICHTHYS UMATILLA*)

Umatilla dace is a hybrid species of speckled and leopard dace (Cannings and Ptolemy 1998). There are several populations in BC, each of which is presumably divergent from one another. They are found in the Similkameen, Kettle, Kootenay, Columbia and Slocan rivers, as well as Otter Creek (Cannings and Ptolemy 1998), although they have not been reported in Otter Creek since 1990 (Haas 1998). Collection of Umatilla dace from any location is often very sporadic (Hughes and Peden 1989, Haas 1998). Elsewhere their range extends to Umatilla, Oregon, Washington State in the Kettle River, and possibly in northern rivers of the Snake River drainage in Oregon and Idaho (Cannings and Ptolemy 1998). In BC, Umatilla dace are Red listed (CDC 2000). This species inhabits warm, fast flowing, clean, bouldery rivers (Hughes and Peden 1989, Peden and Orchard 1993, Cannings and Ptolemy 1998), but has been found in reservoirs in areas with large substrate and a recordable current (Hughes and Peden 1988). It is thought that Umatilla dace use the interspaces of the boulders and rocks as refuge from variable water flows, as they are found in areas with enough flow to prevent the accumulation of fine sediments (Hughes and Peden 1989). In BC, Umatilla dace are found in sympatry with leopard dace, but prefer faster flowing water than leopard dace (Cannings and Ptolemy 1998).

Spawning is thought to take place during spring and summer (Cannings and Ptolemy 1998), but no investigation into the reproductive behaviour or ecology of Umatilla dace has been done. Juveniles were found in shallow, cobble habitat, while adults were in water ≥ 1.3 m deep, associated with very large boulders (≥ 1 m diameter) (Hughes and Peden 1989, Peden and Orchard 1993). Umatilla dace are benthic, and at colder temperatures are thought to move to deeper water or deeper in the substrate (Haas 1998).

REDSIDE SHINER (*RICHARDSONIUS BALTEATUS*)

Redside shiners are found only in North America, west of the Rocky Mountain range, between the Peace River, western Alberta, south through BC to Nevada and Utah (Scott and Crossman 1973). Redside shiners have been introduced into the Colorado River. In BC, this species occurs in the upper reaches of the Nass, Skeena, Klinaklini, and Homathko rivers, and the Fraser and Columbia river drainages. Redside shiners are not found on any of the coastal islands.

Redside shiners inhabit the littoral-produndal zone of lakes (Beauchamp et al. 1995), as well as the limnetic zone (Crossman 1959, Narver 1967, Scarsbrook and McDonald 1973). Often they are associated with vegetation (Brett and Pritchard 1946b, Johannes and Larkin 1961, Scott and Crossman 1973). In Chub Lake, BC, redside shiner were present in water above the thermocline (< 7 m) (Narver 1967). Adult and juvenile (large and small) redside shiners exhibit complex daily and seasonal horizontal and vertical migrations where they move randomly through the nearshore area, and move out to the surface of deeper water at night (Crossman 1959, Johannes and Larkin 1961). Between May and July, redside shiners can be found along fairly shallow inshore areas, where the smaller fish are closer to shore then the large fish (Crossman 1959, Johannes and Larkin 1961). Beginning in late-July and September in Paul Lake, BC, they move to deeper offshore areas between 3 - 10 m deep, and sometimes are found deeper than 10 m (Crossman 1959). Scarsbrook and McDonald (1973) caught redside shiners in the limnetic zone of Babine Lake, BC. When in streams, redside shiners inhabit relatively fast streams and tributary streams to lakes (Weisel and Newman 1951, Lindsey and Northcote 1963, Porter and Rosenfeld 1999). In streams and rivers of the Nazko River drainage, BC, juvenile redside shiner are found in slow moving backwater areas in water < 0.5 m deep, over gravel substrate (Porter and Rosenfeld 1999). Adult redside shiners were found in similar habitat to the juveniles, however adults inhabited slightly faster water in glides and associated with aquatic vegetation and woody debris.

Redside shiners migrate to small lake tributary streams to spawn (Lindsey and Northcote 1963). Spawning initiates when water temperatures reach 10°C in late-April. Males arrive earlier on the spawning grounds. Spawning takes place almost continuously from May to late-July or early-August in BC (Weisel and Newman 1951, Lindsey and Northcote 1963). Redside shiner spawn in riffles over gravel substrate in shallow water (0.1 m) during the day and night (Weisel and Newman 1951, Lindsey 1953, Lindsey and Northcote 1963). Spawning groups can be as large as 30 - 40 individuals, with individuals, particularly males spawning more than once (Weisel and Newman 1951, Lindsey and Northcote 1963). The demersal adhesive eggs are emitted into the water and adhere to gravel and vegetation (Weisel and Newman 1951, Lindsey and Northcote 1963). Eggs hatch within three to seven days at 21 - 23°C and within 15 days at 12°C (Weisel and Newman 1951, Scott and Crossman 1973). Ten days after hatching, young-of-the-year move downstream at night to the lake (Lindsey and Northcote 1963).

Upper lethal temperature limit is 25 - 28°C (Black 1953). Sexual maturity of redside shiners is at three years of age and maximum age is often five to six years (Lindsey and Northcote 1963), however an individual from Shumway Lake, BC was estimated to be six to seven years old (Scott and Crossman 1973).

TENCH (*TINCA TINCA*)

Tench are native to rivers and lakes of northern Europe, and Arctic Ocean drainages of Asia (Scott and Crossman 1973). They were brought to North America for the World's Fair in Seattle in the early part of the 1900's (Dymond 1936). British Columbia is the only province in Canada where tench occur (Scott and Crossman 1973). They inhabit Osoyoos, Christina, and Tugulnuit lakes (Scott and Crossman 1973), and further north into the Columbia River and Okanagan River systems (BC Fisheries 2000a). Tench are largely ignored in BC waters, but in Europe they are caught as a sport, food and pet fish (Scott and Crossman 1973). In BC, these fish most likely inhabit shallow water in sandy and muddy bottomed areas of lakes (G. Haas, BC Fisheries, 2204 Main Mall, Vancouver, BC, V6T 1Z4, personal communication.).

Information on their biology comes from Europe. Tench are slow-moving and inhabit mud bottomed lakes, ponds and still waters in lower reaches of rivers which are heavily vegetated (Scott and Crossman 1973). They spawn in shallow, weedy areas of lakes in June and July (Scott and Crossman 1973). Tench are thought to mature after four years (Scott and Crossman 1973). Tench may live between 20 - 30 years, and reach a maximum size of 60 cm (Wheeler 1969, Scott and Crossman 1973).

SUCKERS (*CATOSTOMIDAE*)

LONGNOSE SUCKER (*CATOSTOMUS CATOSTOMUS*)

Longnose suckers are found throughout BC, except on the coastal islands (Scott and Crossman 1973). Longnose suckers are the most widespread sucker species in North America, ranging from Labrador and Maryland to Washington and Alaska (Scott and Crossman 1973). They are found primarily in clear, cold water lakes (Dymond and Scott 1941, Rawson 1951, Dryer 1966, Emery 1973), but also in rivers (Dymond and Scott 1941) and brackish waters (Scott and Crossman 1973). Upper lethal temperature limit is 27°C (Black 1953). Longnose suckers usually inhabit the bottom of lakes and streams (Scott and Crossman 1973), and can be found at great depths (Clemens et al. 1939, Rawson 1951, Dryer 1966, Scott and Crossman 1973). In Okanagan Lake, BC, longnose suckers can be caught as deep as 60 m (Clemens et al. 1939). In Great Slave Lake, NWT, longnose suckers were most common between 1 - 24 m depths and rarely deeper than 30 m (Rawson 1951, Harris 1962). In Chub Lake, BC, longnose suckers were present above the thermocline in water < 7 m deep (Narver 1967).

Spawning takes place in lake tributary streams, or on lake shores (Harris 1962, Scott and Crossman 1973). Timing of spawning depends on latitude, with more north populations spawning later (June) than southern populations (April) (Scott and Crossman 1973, Morrow 1980). Spawning occurs from ice break-up to mid-June in Great Slave Lake (Harris 1962). Migration into spawning streams begins when water temperatures reach 5°C (Scott and Crossman 1973), but ceases once temperatures reach 15°C (Harris 1962). In streams, spawning takes place over gravel and cobble substrates in 0.1 - 0.6 m of water, with a velocity of 0.3 - 0.45 m/s (Geen et al. 1966). Their spawning behaviour includes females holding in still water of streams while males wait in the fast current (Morrow 1980). The females move into fast water and will mate with one or several males over the course on an hour. The adhesive eggs are scattered, then they sink and attach to the course substrate (Scott and Crossman 1973, Morrow 1980). Adults migrate back to the lake shortly after spawning (Morrow 1980). Eggs hatch within eight days at 15°C, or 11 days at 10°C, but probably take up to two weeks within the stream (Scott and Crossman 1973). After hatching the young-of-the-year remain in the gravel for one to two weeks, after which they drift downstream to the lake (Geen et al. 1966, Bailey 1969, McPhail and Lindsey 1970, Scott and Crossman 1973).

Once in the lake, young-of-the-year moved into quiet, shallow water with vegetation where they acquire food and shelter (Brown and Graham 1953, Edwards 1983). Young-of-the-year longnose suckers may use boulders and rubble during the day (Edwards 1983). When still small, juvenile longnose suckers are plankton feeders and inhabit shallow weedy areas (Edwards 1983) with a slight current (Johnson 1971), but switch to benthic feeding as they grow (Bradbury et al. 1999, Morrow 1980). Feeding is over sand or mud bottomed areas (Emery 1973). Dryer (1966) stated that adult longnose suckers move offshore during the fall. Juvenile and adult longnose suckers were found in water 1 - 13 m deep in Lac La Martre, NWT (Libosvarsky 1970). In an Ontario lake, longnose suckers were found at highest abundance 0.1 - 1.5 m from the bottom in 8 - 12 m of water at night (Emery 1973). Adult longnose suckers usually only move into tributary streams for spawning or overwintering (Harris 1962).

Maximum age and age at sexual maturity vary greatly thoughout the range. In BC, sexual maturity ranges from five to seven years of age, and spawning will continue to 10 - 12 years of age (Scott and Crossman 1973). Sexual maturity in Great Slave Lake was estimated at seven years of age and maximum life spawn at 10 - 12 years of age (Harris 1962), but some have been found up to 19 - 24 years of age

(Keleher 1961, Scott and Crossman 1973). Populations in the south have a higher occurrence of individuals that spawn in successive years (Scott and Crossman 1973).

SALISH SUCKER (*CATOSTOMUS SP.*)

Salish suckers have likely arisen as a result of peripheral isolation from longnose sucker populations within the Chehalis River during the major glaciations of the Pleistocene (McPhail 1967, McPhail and Lindsey 1986, Cannings and Ptolemy 1998). Currently, the Salish sucker is not considered a distinct species, although there has been no gene flow between longnose suckers and Salish suckers since the most recent glaciation (McPhail 1997b). McPhail and Taylor (1999) suggested the scientific name for the Salish sucker to be *Catostomus carli*. Salish suckers are considered endangered in Canada and BC (McPhail 1987, CDC 2000), because of their limited distribution and present steady decline (Haas 1998, Pearson 1998). The population decline is thought to be due to habitat loss (Pearson 1998). In BC, this species is present in five stream systems in the lower Fraser River, including Bertrand, Cave, Fishtrap, Pepin creeks and the Salmon River (McPhail 1997b, Cannings and Ptolemy 1998, Pearson 1998). Salish suckers used to be present in Little Campbell River, and Salwein Creek, although no individuals have been collected in the Little Campbell River since 1976 (McPhail 1987, Cannings and Ptolemy 1998), and Salwein Creek since 1992 (Inglis et al. 1992). Some Salish suckers were present in Howe Creek, a tributary to Bertrand, however no individuals have been collected there for some time (Inglis et al. 1992, 1994). Salish suckers are present in two lakes and possibly a few rivers in the Puget Sound region of Washington state (McPhail and Taylor 1996, Cannings and Ptolemy 1998, Pearson 1998). Where present, Salish suckers are often at very low densities, so absences from collections do not necessarily mean that the fish does not occur in a location (Pearson 1998).

British Columbian populations of Salish suckers inhabit small, lowland streams and ponds, while lake-dwelling and stream-dwelling populations exist in Washington State (McPhail 1987). In streams, Salish suckers are most commonly found in fairly slow flowing water over sand or silt substrate associated with vegetation and overhead cover (Inglis et al. 1992). Salish suckers can inhabit fast water at a range of depths (Pearson 1998).

Spawning begins when water temperatures reach 7 - 8°C, usually in March or April (McPhail 1987), but ripe individuals have been collected during August at water temperatures ≥ 20°C (Inglis et al. 1992, McPhail and Taylor 1996). Spawning is over fine gravel substrate in fast flowing (≤ 0.5 m/s) riffle habitat (McPhail and Taylor 1996). No nest is built during spawning (Pearson 1998). The adhesive eggs are scattered over the coarse substrate (Pearson 1998). Incubation time is unknown. Young-of-the-year and juveniles prefer areas with abundant overhead cover, in habitats such as silt bottomed pools, long glides, shallow riffles (Inglis et al. 1992), and ponds (Pearson 1998). Adults are often only found in riffles during spawning, and prefer slow flowing, deeper areas in pools and glides (Inglis et al. 1992), and possibly off-channel habitat during the winter (Pearson 1998). Sexual maturity is at age two for males and age three for females (McPhail and Taylor 1996), and it is assumed that maximum life span is at four years of age (McPhail 1987, Inglis et al. 1992).

BRIDGELIP SUCKER (*CATOSTOMUS COLUMBIANUS*)

Bridgelip suckers have a limited distribution in northwestern North America. In BC, this species occurs in the Columbia River drainage in Erie and Lower Arrow lakes and the East Kootenay River, Osoyoos Lake, and the Similkameen River (Scott and Crossman 1973). They also occur in the Fraser River drainage, in Nicola Lake, the North Thompson and Quesnel rivers and other tributary rivers from the lower valley to Prince George (Carl et al. 1967). Elsewhere, bridgelip suckers are found in the Columbia River system in Nevada, Idaho, central Oregon and Washington states (Scott and Crossman 1973). Although present in lakes and slow, sand and mud bottomed areas of rivers, this species is most common in small, swift rivers that have abundant gravel to rocky substrates. The mouth structure of the bridgelip sucker suggests that it obtains food by scraping algae and invertebrates off rocks (Carl et al. 1967, Dauble 1980). Very little information is available for this species.

Spawning is assumed to occur during spring, as ripe individuals were captured during June near Prince George, BC and young-of-the-year were collected during July in Idaho (Scott and Crossman 1973). Dauble (1980) observed this species spawning in mid-April to June in the central Columbia River. Spawning is initiated when water temperatures reach 6 - 10°C, and spawning peaks at 8 - 13°C (Dauble 1980). Dauble (1980) captured newly emerged bridgelip suckers during mid-June in water 0.1 - 0.6 m deep in mud and rock bottomed pools. Juvenile and adult bridgelip suckers were collected in water 1 - 2 m deep and deeper at the tailout of pools and riffles in the main current over boulder substrate. There is debate as to the size at which sexual maturity occurs. Smith (1966) estimated 12.7 cm, and Carl et al. (1967) stated 38.1 cm. Bridgelip suckers are known to hybridize with largescale suckers (Scott and Crossman 1973) and may hybridize with mountain suckers (Campbell 1992).

WHITE SUCKER (*CATOSTOMUS COMMERSONI*)

White suckers are present in the Skeena, Peace and upper Fraser rivers in north-central BC (Scott and Crossman 1973). White suckers have a large distribution across North America, from Ungava and Labrador to western Georgia and Oklahoma, north to the Mackenzie River delta (Scott and Crossman 1973). White suckers are commonly found in warm, shallow water in small lakes, bays of large lakes and tributary streams of lakes (Dymond and Scott 1941, Rawson 1951, Emery 1973, Scott and Crossman 1973, Kelso 1974, Johnson 1977, Lyons 1987).

White suckers spawn in spring (Emery 1973) between May and June (Nelson 1968c). Spawning takes place in inlet or outlet streams of lakes when water temperatures reach at least 10 - 12°C (Nelson 1968c), although some individuals spawn along lake margins (Scott and Crossman 1973). In some areas, part of the population will spawn in the lake, and the other part in the tributaries (Scott and Crossman 1973). Spawning is usually in flowing water (slow to rapids) over gravel substrate, often near pools 0.6 - 1.2 m deep (Nelson 1968c, Scott and Crossman1973). Adults form schools of one female to several males and travel close to the bottom (0.2 - 2.0 m above the bottom) during spawning (Emery 1973, Scott and Crossman 1973). The eggs are scattered over and adhere to the gravel substrate or drift to slower water (Scott and Crossman 1973). Eggs hatch in one to two weeks, and the young-of-the-year remain in the stream for one to two weeks more before drifting downstream to the lake (Scott and Crossman 1973).

Upon entering the lake, young-of-the-year white suckers remain in shallow water along the shore (Corbett and Powles 1983, Lyons 1987) where they form schools and feed on plankton (McPhail and Lindsey 1970). At night (McPhail and Lindsey 1970), or when water temperatures reach 30°C, young-of-the-year move to deeper water (Corbett and Powles 1983). By late summer, young-of-the-year white suckers move to the bottom (McPhail and Lindsey 1970). Juveniles inhabit shallow waters (Johnson 1977, Lyons 1987), where they feed near the surface on plankton but move to deeper areas once they reach 16 - 18 mm in length (Scott and Crossman 1973, Parsons 1975, Corbett and Powles 1983). Juvenile white suckers were captured to 11 m deep in Lake Huron (Berst and McCombie 1963). Adults are commonly found in shallow areas of lakes (Berst and McCombie 1963, Emery 1973, Kelso 1974, Johnson 1977, Lyons 1987), near river mouths (Rawson 1951). At night white suckers can be found between 0.5 - 10 m of water near the bottom (0.2 - 1.5 m), and during the day, they can be found in water 15 - 20 m deep (Emery 1973). Adults typically are benthic feeders, yet occasionally eat detritus (McPhail and Lindsey 1970, Parsons 1975, Ahlgren 1990). Adult white suckers associate with submerged woody debris (Moring et al. 1986, Hubert and Rahel 1989).

Young-of-the-year grow rapidly during their first year, and growth slows as the fish grow older, however growth rate varies greatly from lake to lake (Beamish 1970, Scott and Crossman 1973). Sexual maturity is between five to eight years of age (Scott and Crossman 1973). Maximum age seems to be 15 - 17 years of age (Beamish 1970, Scott and Crossman 1973). White suckers are known to hybridize with mountain and largescale suckers (Nelson 1968c, Scott and Crossman 1973). In nine of 11 lakes sampled in BC, white suckers hybridized with largescale suckers (Nelson 1968c).

LARGESCALE SUCKER (*CATOSTOMUS MACROCHEILUS*)

The range of the largescale sucker is largely constrained within mainland BC. This species occurs in the Peace River drainage, the Nass River and south to the Columbia and Fraser River drainages (Scott and Crossman 1973). Largescale suckers are absent from streams that flow into the Strait of Georgia, except for the Fraser River. Largescale suckers can be found south to the Sixes River in Oregon, western Utah and northern Nevada. This species is most commonly found in weedy areas of lakes associated with the bottom, in backwaters and in stream mouths in water < 15 m deep (Clemens et al. 1939, Scott and Crossman 1973).

Spawning takes place during mid-May to late-June in central BC (Nelson 1968c), and mid-April in the lower Fraser Valley (McPhail and Lindsey 1970). Spawning usually takes place in small lake outlet or inlet streams in water 10 - 12°C (Nelson 1968c), but may occur along lake margins (McPhail and Lindsey 1970). Spawning is over sand substrate in deep areas (Nelson 1968c). Eggs are adhesive and hatch within two weeks (McPhail and Lindsey 1970). During early summer, young-of-the-year largescale suckers form schools and swim in midwater or near the surface feeding on crustaceans (McPhail and Lindsey 1970). By the fall, the young-of-the-year settle to the bottom and start feeding on benthic organisms amongst emergent vegetation (Clemens et al. 1939, McPhail and Lindsey 1970). Adults feed primarily on benthic invertebrates within the muddy bottom of lakes (Carl 1939, Ricker 1952), or fish eggs (Patten and Rodman 1969). Sexual maturity is around five years for males and six years for females (McPhail and Lindsey 1970). Clemens et al. (1939), collected a 15 year old individual from Woods Lake, BC. Upper lethal temperature limit for largescale suckers is 29°C (Black 1953). Largescale suckers are known to hybridize with white suckers (Nelson 1968c), and bridgelip suckers (Scott and Crossman 1973).

MOUNTAIN SUCKER (*CATOSTOMUS PLATYRHYNCHUS*)

In BC, mountain suckers are found in only a few locations in the southern region of the province (Cannings and Ptolemy 1998). Within these locations, mountain suckers are neither abundant nor widespread (Scott and Crossman 1973). They have been observed in the Tulameen River and Wolfe Creek, the mainstem Similkameen, North Thompson (near Heffley Creek), and Fraser rivers (near Herrling Island) (Scott and Crossman 1973, Cannings and Ptolemy 1998). In BC, mountain suckers are Blue listed (CDC 2000). Elsewhere in Canada, the mountain sucker is found in the Milk and Saskatchewan rivers in Saskatchewan and Alberta (Scott and Crossman 1973, Cannings and Ptolemy 1998). In the United States, this species is found in parts of the Columbia, Milk, Upper Missouri, North Fork Feather, and Green rivers in Wyoming, Idaho, Washington, Oregon, Montana, South Dakota, Utah, Colorado, California and Nevada states (Cannings and Ptolemy 1998). Mountain suckers are only occasionally found in lakes (Smith 1966). They are most commonly found in cool, small, moderate current mountain streams < 12 m wide and 1 m deep (Campbell 1992). Within the streams, mountain suckers generally associate with a variety of substrates, from mud to boulder and rubble, and can be found near aquatic vegetation although this is not always true (Smith 1966, Campbell 1992). Preferred water temperatures range from 10 - 28°C during the summer and near 0°C in the winter (Reed 1962).

In Montana, spawning takes place in late spring to early summer (June to July), when water temperatures reach 10.5 - 18.8°C (Hauser 1969, Scott and Crossman 1973). The demersal and possibly adhesive eggs are released into the water column in riffles adjacent to pools (Hauser 1969). Once spent, adults move into deep pools with cover, and form small schools independent from other suckers (Scott and Crossman 1973). Presumably eggs take similar time to hatch as other sucker species (eight to 14 days) (Cannings and Ptolemy 1998). Young-of-the-year remain in moderate current, shallow water (< 0.4 m), such as run habitat, associated with cover (Hauser 1969). Juveniles move into deeper, vegetated side channels or pools that have very little current. Adults can be found adjacent to pools in water between 1 - 1.5 m with a current of 0.5 m/sec, and associated with bank cover.

Females mature between ages three to five, while males mature a year earlier (Hauser 1969), however males may mature after one to two years (Smith 1966). Maximum age is thought to be nine years of age (Hauser 1969). Mountain suckers will hybridize with longnose and white suckers (Scott and Crossman 1973), and may hybridize with bridgelip suckers (Campbell 1992).

BULLHEAD CATFISHES (*ICTALURIDAE*)

BLACK BULLHEAD (*AMEIURUS MELAS*)

Black bullheads were introduced to the Columbia River in Washington State, and have since spread into Oregon and BC (Scott and Crossman 1973). Currently in BC, black bullheads are found in Osoyoos Lake, in the Okanagan River drainage and in the main Columbia River drainage to Revelstoke, BC (Scott and Crossman 1973, BC Fisheries 2000a). The natural range of black bullheads is restricted to the freshwaters of North America, from Montana and New Mexico east to the Atlantic coastline and south-western Ontario (Scott and Crossman 1973). Black bullheads are more tolerant to pollutants than other bullhead species. This species is a bottom feeder, and is often found in the lower section of low gradient, small to medium sized streams, slow backwaters of larger rivers, and silty bottomed areas of lakes, and ponds.

Black bullheads spawn during the spring (May to June) and summer (June to August), depending on location (Forney 1955, Scott and Crossman 1973). Forney (1955) reported peak spawning during July in Iowa. Spawning is thought to commence once water temperatures reach 21°C (Scott and Crossman 1973). Females excavate a nest on the bottom over gravel, silt and detritus, within moderately to heavily vegetated areas in shallow areas. The males and females have an elaborate courtship ritual (Wallace 1967). Eggs are deposited in small batches within the same nest over the period of one day (Scott and Crossman 1973). Both parents fan the eggs with their fins and guard the eggs until they hatch (Scott and Crossman 1973). At high temperatures, eggs hatch within five days. The newly hatched young-of-the-year form a loose school and stay close to the parents which will guard the young for several weeks until they reach a size of 25 mm.

Average maximum age is probably at four years old (Carlander 1969), but individuals as old as eight to nine years of age have been recorded in Iowa (Scott and Crossman 1973). Upper lethal temperature limit of this species is 35°C (Black 1953).

BROWN BULLHEAD (*AMEIURUS NEBULOSUS*)

Brown bullheads were introduced to BC in the Lower Fraser River and southern Vancouver Island between Victoria and Nanaimo (Scott and Crossman 1973). Presently, this species is found in other locations of Vancouver Island, the Lower Fraser River, the Okanagan River drainage and the upper Kootenay River drainage (BC Fisheries 2000a). The native range of the brown bullhead extends from southern Manitoba, to the Great Lakes and Nova Scotia, south to Florida and eastern Texas (Scott and Crossman 1973). Brown bullheads are bottom feeders, and are typically found in shallow to deep, warm water ponds, small lakes, and bays of large lakes, as well as large, slow-moving rivers that have abundant aquatic vegetation (Scott and Crossman 1973, Kelso 1974). In Lake Ontario, brown bullheads were captured in a shallow bay (4 m) with a temperature over 16°C, up to 150 m from shore (Kelso 1974).

In Canada, spawning takes place during May and June when water temperatures reach at least 21.1°C (Scott and Crossman 1973). In the southern range, spawning will continue to September, with most populations spawning twice within a season. The male or female will build the nest in shallow water along lakes shore, bay coves or in creek mouths. Nests are built in sand or mud near cover such as rocks, trees, or stumps. Nests have also been found in boat fenders hollow stumps, and tires. The mating pair engage in an elaborate mating ritual before the eggs are laid in the nest. Both parents remain by the nest to guard and fan the eggs. Eggs hatch within six to nine days at 20 - 23.3°C. Adults continue to guard the young-of-the-year at the nest for up to three weeks, or until they reach a size of 12.2 cm.

Age of sexual maturity is usually at three years (Scott and Crossman 1973). Maximum age of brown bullheads is six to eight years. Lethal water temperature is 35°C (Cairns 1956).

PIKE (*ESOCIDAE*)

NORTHERN PIKE (*ESOX LUCIUS*)

Northern pike are found in the northeastern corner of BC within the Peace River drainage downstream of the Peace River Canyon, and the headwaters of the Alsek and Taku rivers (McPhail and Lindsey 1970, Scott and Crossman 1973). They are found in Pine Lake, of the Alsek River drainage, and Taysen Lake in the Taku River drainage (McPhail and Lindsey 1970). The northern pike is found only in freshwater and has a circum polar distribution, from Scandinavia to Labrador (McPhail and Lindsey 1973). Northern pike are a slow-water, predatory species, and are most commonly found in shallow areas of shallow lakes, marshes, backwater sloughs and sometimes slow rivers (Dymond and Scott 1941, Libosvarsky 1970, McPhail and Lindsey 1970, Johnson et al. 1977, Ford et al. 1995). They inhabit lakes that have between 60 - 80% of the lake area as littoral zone (Johnson et al. 1977), with at least 30%, but up to 80% vegetation cover (Grimm and Backx 1990, Casselman and Lewis 1996, Randall et al. 1996).

Spawning takes place during late-March and early-June (June 1970, McPhail and Lindsey 1970). In colder areas, spawning starts after ice break-up (McPhail and Lindsey 1970), when water temperatures are between 4.4 - 12°C (Scott and Crossman 1973, Casselman and Lewis 1996). Northern pike spawn in sheltered areas with moderate water exchange and extensive submergent or emergent vegetation, such as sedges and grasses (Threinen et al. 1966, McPhail and Lindsey 1970, Scott and Crossman 1973, Casselman and Lewis 1996). Water depth during spawning is usually between 0.1 - 0.7 m, and averages between 0.2 - 0.4 m (Casselman and Lewis 1996). Preferred spawning substrate is well oxygenated detritus and elaborate root systems of emergent plants (Casselman and Lewis 1996), but spawning will occur over sand to mud substrates (Scott and Crossman 1973, Holland and Huston 1984). Often during spawning one large female may be accompanied by two smaller males (Scott and Crossman 1973). The adhesive, demersal eggs are scattered over the vegetation during the day and abandoned by the parents (McPhail and Lindsey 1970, Ford et al. 1995). Eggs adhere to the mats of vegetation or stems of plants (Casselman and Lewis 1996). Eggs hatch within four to five days when temperatures are between 17.8 - 20°C, but usually take 12 - 14 days at lower temperatures (Scott and Crossman 1973). The newly hatched larvae remain attached to the vegetation for up to 10 days (Ford et al. 1995), so that they do not fall into the oxygen depleted substrate characteristic of northern pike spawning areas (Craig 1996). Young-of-the-year rear in mucky backwater areas, that are dense (40 - 90% coverage) with submergent and emergent vegetation (Holland and Huston 1984, Casselman and Lewis 1996). Submergent vegetation is preferred over emergent vegetation (Casselman and Lewis 1996) as it provides protection from predators and adverse winter conditions (Grimm 1989, Grimm 1994). As the young-of-the-year grow during their first season, they move from the shallow spawning areas to deeper water (1.0 - 2.5 m)

(Casselman and Lewis 1996). Growth is rapid for the first three years, but is dependent on growing season, water temperature and food availability (Scott and Crossman 1973). Optimal temperature for growth in young-of-the-year was recorded as 22 - 23°C, and 19 - 21°C for juveniles and adults (Casselman 1978, Casselman and Lewis 1996).

As northern pike grow, they move to deeper (< 9 m deep), and less vegetated areas (Libosvarsky 1970, Bregazzi and Kennedy 1980, Chapman and Mackay 1984a,b, Casselman and Lewis 1996). Juvenile northern pike were captured in areas with moderate to high density of submergent vegetation, while adults were found in areas with moderate to low density of submergent vegetation (Cook and Bergersen 1988, Casselman and Lewis 1996). The switch to submergent from emergent vegetation by juveniles and adults is thought to be due to their ambush feeding habits (Casselman and Lewis 1996). Juveniles and adults associate with detritus to mud substrates, yet avoid sandy areas (Diana et al. 1977, Ford et al. 1995, Casselman and Lewis 1996, Eklov 1997). Adult northern pike usually stay within the shallow, vegetated regions of the lake during spring and fall (Scott and Crossman 1973). They will move to deeper water during the summer when water temperatures increase (Scott and Crossman 1973), and during the winter as ice-cover forms, vegetation dies back and oxygen becomes depleted (Casselman 1978, Cook and Bergersen 1988, Derksen 1989). Northern pike sometimes are found in limnetic areas (Chapman and MacKay 1984a,b, Cook and Bergensen 1988, Ford et al. 1995). They have been found offshore in water 2 - 25 m deep in Great Slave Lake, NWT (Rawson 1951), and > 30 m deep during the summer in Lake Nipigon, ON (Scott and Crossman 1973). Typically this species is fairly sedentary, although extensive spring (spawning) and fall migrations have been recorded (Scott and Crossman 1973, Ford et al. 1995).

Sexual maturity for females is at age five and males at age four in more northern lakes (Miller and Kennedy 1948), and between three to four years for females and two to three years for males in southern lakes (Scott and Crossman 1973). Northern pike are long-lived, and may live more than 25 years in some areas (Rawson 1959, Miller and Kennedy 1948), although older specimens have been collected (see McPhail and Lindsey 1970, Scott and Crossman 1973).

SMELTS (*OSMERIDAE*)

SURF SMELT (*HYPOMESUS PRETIOSUS*)

Within Canada, surf smelt are only found within BC, in the lower Fraser River to the mouth of the Pitt River and occasionally in Pitt Lake (McPhail and Carveth 1993a). Surf smelt are typically a marine species, and spawn in in-shore marine areas (Haas 1998). The lower Fraser River is the only consistent area where surf smelt are caught in freshwater (Haas 1998). The ecology of surf smelt in freshwater is largely unknown. Elsewhere, surf smelt are found from Monterey Bay, California to Chignik Lagoon, Alaska (Phinney and Dahlberg 1968).

Surf smelt spawn on beaches in light to moderate surf from March to May (Morrow 1980). Spawning will take place at the extreme low tide line to mid-way up the beach (Thompson et al. 1936, Yap-Chionggo 1941). One female will spawn with up to five males in the shallow (2.5 - 5 cm deep) tide water (Morrow 1980). Spawning substrate is important during site selection, and consists of coarse sand to fine gravel (Morrow 1980). The fertilized egg adheres to the substrate via a stalk (pedicle) that forms from the outer membrane of the egg (Morrow 1980). This stalk allows the egg to sway in the current to increase aeration (Morrow 1980). Eggs hatch within 8 - 11 days at 12.2 - 15.5°C (Morrow 1980). Once the larvae hatch, they are phototrophic and move towards the light (Morrow 1980). Once they are at least 3.5 cm long, some surf smelt may move up into rivers to feed on aquatic invertebrates (McAllister 1963, Morrow 1980), however their stay in freshwater is presumably short-lived (Morrow 1980). Adult surf smelt are thought to move offshore, only to return to shallow water to spawn once they reach sexual maturity at age one or two (Morrow 1980). Maximum life expectancy is two years for males and three years for females (Morrow 1980).

RAINBOW SMELT (*OSMERUS MORDAX*)

Rainbow smelt have a very limited distribution within BC. They are known from Barkley Sound off Vancouver Island, and in the lower reaches of the Stikine River in northern BC (Scott and Crossman 1973, McPhail and Carveth 1993a, Haas 1998). Freshwater collections have only come from the Stikine River (Haas 1998). Elsewhere the rainbow smelt is found along the coast of Alaska to Cape Bathurst, and along the Arctic coast in Asia and Europe (Scott and Crossman 1973, Haas 1998). The rainbow smelt also occurs along the Atlantic Coast of North America from Labrador to New Jersey, and has been introduced to various locations including the Great Lakes (Scott and Crossman 1973). This species is anadromous, although landlocked populations do exist primarily in the Great Lakes, and along the east coast of North America (Scott and Crossman 1973, Scott and Scott 1988). Most of the information regarding freshwater resident rainbow smelt comes from work done on the Great Lakes populations.

Spawning migration from the ocean or lake begins shortly after ice break-up when water temperatures reach at least 2 - 4°C, usually from March to May depending on the location (Scott and Crossman 1973, Morrow 1980). Rainbow smelt migrate very short distances upstream to spawning areas, often from a few hundred meters to a few kilometres (McKenzie 1964, Morrow 1980). If weather conditions are unfavourable, rainbow smelt will spawn offshore on gravel shoals in salt water (Rupp 1965, Leim and Scott 1966, Scott and Crossman 1973, Morrow 1980). Water velocity is thought to be the most important factor during spawning (Buckley 1989), as rainbow smelt are known to spawn over a range of substrates (fine gravel to boulders), and near submerged logs and vegetation (Scott and Crossman 1964, Morrow 1980). Most commonly however, spawning occurs over gravel substrate in moderately flowing water, $\leq$ 1.3 m deep (Scott and Crossman 1973, Bradbury et al. 1999).

Sexual maturity is usually at two years of age (Morrow 1980), although the spawning population consists of three year olds and some older fish (McKenzie 1964). One female, accompanied by sometimes two males, emits their gametes into the water usually at night (Scott and Crossman 1973, Morrow 1980). After spawning, the adults immediately move back to the ocean or lake from where they originated (Scott and Crossman 1973, Morrow 1980). Adults either live to spawn another year or die after spawning (Morrow 1980). The eggs become adhesive after release, and attach to the substrate (Scott and Crossman 1973) via a stalk that is formed by the outer membrane of the egg (Rupp 1965). This stalk allows the egg to sway in the current to increase aeration (Scott and Crossman 1973, Morrow 1980). Eggs hatch within 29 days at 6 - 7°C, or 10 days at 15°C (Hoover 1936, McKenzie 1964). After the eggs hatch, the larvae slowly drift downstream to the ocean or lake where they eventually rear (McKenzie 1964, Scott and Crossman 1973, Morrow 1980, Scott and Scott 1988). By mid-August, young-of-the-year and juvenile rainbow smelt form schools over gravel and sand beaches, or within eelgrass beds (Scott and Crossman 1973, Buckley 1989). In the Great Lakes, rainbow smelt were found in water $>$ 10 m deep (Dryer 1066, Emery 1973).

LONGFIN SMELT (*SPIRINCHUS THALEICHTHYS*)

In BC, anadromous longfin smelt ascend the lower Fraser River to at least the Pitt River (McPhail and Carveth 1993a), and the Taku River in northern BC (Scott and Crossman 1973). There are landlocked populations of pygmy longfin smelt within Harrison and Pitt lakes in the Fraser River system (McPhail and Carveth 1993a, Cannings and Ptolemy 1998). Landlocked populations also exist in Lake Washington, Washington State (Scott and Crossman 1973). In BC, pygmy longfin smelt are Red listed (CDC 2000). The distribution of longfin smelt is restricted to the Pacific coast of North America between San Fransisco, California and the Gulf of Alaska (McAllister 1963) or Bristol Bay, Alaska (McPhail and

Lindsey 1973). Along the BC coast, longfin smelt are absent from the coastal islands (Scott and Crossman 1973).

Anadromous longfin smelt

For anadromous populations in BC, spawning takes place from October to December (Clemens and Wilby 1961). Spawning is in freshwater streams at locations near the ocean (Clemens and Wilby 1961). Eggs hatch within 40 days at 6.9°C (Scott and Crossman 1973). By April young-of-the-year migrate downstream towards the ocean (Scott and Crossman 1973). In the ocean, longfin smelt remain nearshore, in bays and estuaries (Page and Burr 1991). Longfin smelt mature and spawn by ages two to three in the southern portion of their range (Scott and Crossman 1973). Most adults die after spawning (Scott and Crossman 1973).

Pygmy longfin smelt

The pygmy longfin smelt from Pitt and Harrison lakes have arisen independently from anadromous populations following deglaciation, even though anadromous individuals can be found within Pitt Lake (McPhail and Carveth 1993b, Cannings and Ptolemy 1998). Spawning location is not known in the lakes. Spawning is thought to occur in November and December, as young-of-the-year were found in trawl catches in March (McPhail 1993). Both adult and juvenile pygmy longfin smelt undergo diel migrations, although adults are usually found in deeper water than juveniles (Cannings and Ptolemy 1998). Typically, this species is found between 7 - 60 m depths in both lakes (Cannings and Ptolemy 1998).

EULACHON (*THALEICHTHYS PACIFICUS*)

Throughout their range, eulachon are anadromous and primarily marine, spending up to 95% of their life within saltwater (Hay and McCarter 2000). Eulachon occur along the west coast of North America, from Klamath River, California to Bristol Bay, the Pribilof Islands and the Bering Sea, Alaska (Scott and Crossman 1973). In BC, eulachon spawn in only 14 rivers on a regular basis and another 19 rivers on an occasional basis (Hay and McCarter 2000). Some rivers include the Fraser, Skeena, Nass, Kemano, Kitlope, Kowesis and Gardner Canal. It is estimated that there are only nine distinct populations of eulachon in BC, which is relatively low compared to the rest of its range. Eulachon are Blue listed in BC (CDC 2000).

Migration to spawning grounds occurs after ice break-up (Scott and Crossman 1973). In BC, spawning typically takes place between March and May (Barraclough 1964). In general, timing of spawning varies with latitude. Southern populations spawn as early as January, and northern populations spawn in May, however in BC this pattern is reversed (Hay and McCarter 2000). In the Fraser River, eulachon spawn in April and May, while in the Nass and Skeena rivers they spawn in late February and early-March. The location of spawning within a single river changes from year to year (Hay and McCarter 2000), but usually eulachon move only short distances into coastal rivers and streams to spawn (Scott and Crossman 1973). In the Fraser River, the main spawning ground is between Chilliwack and Mission, usually in 8 m of water over coarse sand substrate. Spawning has also been observed in lower reaches of the Fraser River (Hay and McCarter 2000). Eulachon are known to spawn in large, turbid rivers to small, clear streams, but all spawning rivers must have a spring freshet. Males arrive at the spawning grounds before females (Scott and Crossman 1973). Water temperature ranges between 4.4 - 7.8°C during spawning. There is no redd built and the adhesive eggs are scattered and abandoned by both parents. After spawning, most adults die (Hay and McCarter 2000), but some that are in good condition will immediately migrate back to the ocean (Barraclough 1964). The outer membrane of the egg forms a stalk, which anchors the egg to the substrate (Hay and McCarter 2000). Eggs hatch within four weeks at 4 - 5°C. The newly hatched young-of-the-year remain in the stream only as long as it takes them to passively move downstream to the ocean (Smith and Saalfeld 1955, Scott and Crossman 1973, Hay and McCarter 2000). Barraclough (1964) estimated sexual maturity to be at age two, while first spawning occurred at age three. Hay and McCarter (2000) reported sexual maturity to be at age three. They also captured young-of-the-year in surface waters (0 - 15 m), as well as in deeper water (20 - 35 m). In the marine environment, all ages of eulachon can be found in moderately deep waters (30 - 210 m), not far offshore (Barraclough 1964).

SALMONIDS (*SALMONIDAE*)

CISCO (*COREGONUS ARTEDI*)

Ciscos (lake herring) are only found in the extreme northeast corner of BC in Maxhamish Lake within the Liard River drainage (Cannings and Ptolemy 1998). Outside of BC they are found from Labrador to the Mackenzie River system, from New York and Illinois to Alberta and Great Bear Lake (Cannings and Ptolemy 1998). In BC, cisco are Red listed (CDC 2000). Typically all cisco species inhabit deep waters of lakes or large rivers (e.g. Hudson River, Scott and Crossman 1973), but are found in shallow (McPhail and Lindsey 1970, Emery 1973), and brackish waters (Dymond and Scott 1941). Ciscos exist in large deep lakes in Ontario at depths between 0 - 160 m (Ferguson 1958, Scott and Crossman 1973). In the shallow Maxhamish Lake, ciscos range between depths of 1.3 - 4 m in mid-summer between near shore and far off shore areas (1.6 km offshore, Cannings and Ptolemy 1998). Ciscos move below the thermocline (from shallower to deeper water) in spring and summer (Ferguson 1958, Scott and Crossman 1973) and move in the reverse direction when water temperatures cool again (Scott and Crossman 1973). In Amisk Lake, Alberta, ciscos were found at depths ranging from 3 - 25 m from June to September (Aku et al. 1997). In Great Slave Lake, NWT, Rawson (1951) caught ciscos between 2 - 100 m depths. Young ciscos are found in shallow nearshore areas (Rawson 1951), especially at night (Emery 1973). At night, juvenile ciscos feed at or near the bottom of the nearshore area (Emery 1973). Young-of-the-year and juvenile ciscos move to deeper water (50 m) during summer when water temperatures rise (Ferguson 1958).

Spawning takes place in water 1 - 3 m in depth, over sandy or gravel substrate during late fall (September to November) as water temperatures decline (McPhail and Lindsey 1970, Scott and Crossman 1973). Eggs are deposited on the substrate and abandoned (Scott and Crossman 1973). In the Great Lakes, spawning may occur on the lake bottom in deep water or suspended within the water column between 9 - 12 m (Scott and Crossman 1973). Ciscos form large aggregations during spawning. Ciscos can reach 16 years of age (Aku and Tonn 1997)

ARCTIC CISCO (*COREGONUS AUTUMNALIS*)

The arctic cisco range is purely within the Arctic Ocean from Cambridge Bay, NWT to Point Barrow, Alaska in North America and within Arctic rivers in northern Europe to Asia (Scott and Crossman 1973). They are absent from the Bering Sea and ascend the Mackenzie River to Camsell Bend (McPhail and Lindsey 1970). In BC, they have been found within the Liard River system (BC Fisheries 2000a), and are Red listed (CDC 2000). Arctic ciscos do not generally occur in lakes. They are an anadromous species and are found in brackish waters and the lower reaches of large rivers (McPhail and Lindsey 1970). They leave salt water in the spring and summer to ascend rivers to spawn (Scott and Crossman 1973). They spawn in late summer and early autumn (McPhail and Lindsey 1970) between July and September (Dillinger et al. 1992) over gravel substrate in fast flowing water (Hatfield et al. 1972, Dryden et al. 1973, Scott and Crossman 1973, Dillinger et al. 1992). Arctic ciscos form large groups during spawning and emit and abandon the eggs over the substrate (Nikolsky 1969, Scott and Crossman 1973). Adults return immediately back to the ocean after spawning (Scott and Crossman 1973). Eggs hatch by spring, and the young move downstream to the estuary (Scott and Crossman 1973). Sexual maturity is reached by ages five to seven in Siberia, and possibly nine to ten years in other areas (Scott and Crossman 1983). The maximum age of arctic ciscos is not known for North America, but is typically eight to nine years in Siberia (McPhail and Lindsey 1970).

LAKE WHITEFISH (*COREGONUS CLUPEAFORMIS*)

Lake whitefish naturally occur in northern BC lakes but are absent from the Stikine and Taku River drainages (Ford et al. 1995). In the mid-part of the 20th century, lake whitefish from eastern Canada were introduced into the Fraser, Okanagan-Columbia, and Kootenay-Columbia river systems (Carl et al. 1959) in an attempt to build a commercial fishery. Lake whitefish are found across North America from the Bering Sea east to Cambridge Bay, Ungava and Labrador and south to the St. Lawrence River and Great Lakes and west across to BC (McPhail and Lindsey 1970, Scott and Crossman 1973). Recently, lake whitefish have been listed by COSEWIC as threatened species in Lake Erie, Ontario (Campbell 1998). Lake whitefish typically inhabit cool deep lakes (Dymond and Scott 1941, Rawson 1951, Godfrey 1955, Ford et al. 1995). McHugh (1939) caught lake whitefish between 0 - 46 m depths in various lakes in the Okanagan Valley, BC. Dryer (1966) found lake whitefish at depths of 80 m in Lake Superior. The lake whitefish population within Dragon Lake, BC was thought to have diverged into two subspecies (a limnetic and a benthic form, Kirkpatrick and Selander 1979, Lindsey 1981, McPhail and Carveth 1993b), however in 1956 these two subspecies were eliminated when the lake was poisoned (Cannings and Ptolemy 1998). Divergence into limnetic and benthic forms was also described by Lindsey (1963) in Squanga Lake, Yukon.

Timing of spawning varies across the range and is dependent on latitude (Lindsey et al. 1970). In BC spawning occurs between mid-September to late January. Lake whitefish will spawn within either rivers or lakes. In rivers, spawning takes place in shallow water over gravel, cobble, boulder and sometimes sand (McPhail and Lindsey 1970, Machniak 1975, Ayles 1976, Morrow 1980, Ford et al. 1995). Spawning in small lakes is generally in water < 10 m deep (Bryan and Kato 1975, Machniak 1975, Ayles 1976, Morrow 1980, Ford et al. 1995, Begout Anras et al. 1999). In large lakes spawning can take place in much deeper water, between 3 - 30 m (Machniak 1975, Ford et al. 1995). In lakes, lake whitefish prefer spawning on rocky reefs (McPhail and Lindsey 1970) or beaches with gravel and rubble substrate (Machniak 1975, Bodaly et al. 1984). Mud is avoided (Machniak 1975), however Bidgood (1972) reported spawning in < 1 m of water over sand-silt substrate in Alberta lakes and Bryan and Kato (1975) reported spawning in the Yukon over silt and emergent vegetation. Lake whitefish may be quite active on the spawning grounds and jump and thrash about (Scott and Crossman 1973). No parental care is given to the eggs (Scott and Crossman 1973).

Young-of-the-year lake whitefish initially are limnetic feeders and switch to benthic feeding as the fish learns the local food availability (Ford et al. 1995). Shifting from limnetic to benthic feeding is associated with an ontogenetic shift in habitat, from shallow to deep water (Ford et al. 1995). In Lake Huron, young-of-the-year lake whitefish were found in shallow, warm (17°C) water associated with emergent vegetation during June and early-July (Reckahn 1970). Once water temperatures increased in July and August, the young-of-the-year moved quickly to 15 m and continued to descend as water temperatures got colder with the onset of winter. In Great Slave Lake, NWT, lake whitefish were found within the shallow nearshore area as late as July (Rawson 1951). In Lac La Martre, NWT, all age classes of lake whitefish were found between 1 - 13 m (Libosvarsky 1970). Rawson (1951) suggested that the presence of this species in shallow water during the summer is associated with the relatively cool temperature of Great Slave Lake compared to more southern lakes.

Adult lake whitefish were caught most often between 10 - 15 m of water in four lakes in the Skeena drainage (Godfrey 1955), and in water < 7 m deep above the theromcline in Chub Lake, BC (Narver 1967). They were caught as deep as 75 m in Great Slave Lake, NWT (Rawson 1951). In an Ontario lake (maximum depth of 17 m), lake whitefish (> 360 mm in length) were found swimming between 0 - 8 m and active in the offshore and nearshore areas (Begout Anras et al. 1999). When in the littoral zone, adult lake whitefish were associated with cobble, boulder and sand substrates. Size and age of maturity ranges between three to thirteen years of age for lake whitefish as timing of maturity is affected by commercial and recreational harvesting (Healey 1975), and latitude (Kennedy 1953). Typically, individuals from harvested populations grow faster and mature sooner than unexploited populations (Healey 1975). Individuals from northern populations mature later than individuals from southern populations. In Ontario, migration to spawning grounds (lake shore or rivers) begins in October as water temperatures cool to between 4.5°C and 10°C (MacKay 1963). Specific information regarding spawning migration timing, and timing of spawning is not well understood for BC populations.

BROAD WHITEFISH (*COREGONUS NASUS*)

The range of broad whitefish in BC is limited to Teslin Lake that straddles the Yukon-BC border (Canning and Ptolemy 1998). The main range of the broad whitefish is in Arctic draining river systems from the Pechora River, in northern Asia to the Bering Sea, across northern Alaska west to the Perry River in the Northwest Territory (Scott and Crossman 1973). It is not found in Great Bear Lake, NWT (Scott and Crossman 1973). Because of their limited distribution within BC, broad whitefish are Red listed (CDC 2000). Broad whitefish are more common in rivers and brackish water than in lakes (McPhail and Lindsey 1970, Valtonen 1970), so the presence of broad whitefish in Teslin Lake is unusual (Haas 1998). In Teslin Lake, broad whitefish coexist with lake whitefish, and associate with the bottom where they feed on benthic organisms (Morrow 1980, Cannings and Ptolemy 1998). There is virtually no information pertaining to the population of broad whitefish in Teslin Lake, as well as their general freshwater ecology in North America. Some work has been done by Valtonen (1970), in the Bay of Bothnia in the Central Baltic. He suggests that the Bay of Bothnia is similar in biota to a large oligotrophic lake, although it is brackish water. Valtonen (1970) found that young broad whitefish were found within the top few meters of water while the adults ranged between depths of 5 - 20 m.

Broad whitefish migrate upstream to spawning areas starting in July and August in the Mackenzie River and into September in the Yukon River (McPhail and Lindsey 1970). Spawning takes place between September and October or November (Cannings and Ptolemy 1998). Spawning may take place over gravel substrate (Valtonen 1970), where eggs are deposited on the substrate and abandoned by the adults (Scott and Crossman 1973). In the Yenisei River, Siberia, broad whitefish mature at around age seven with the oldest individuals reaching 15 years of age (Scott and Crossman 1973).

LEAST CISCO (*COREGONUS SARDINELLA*)

Least ciscos are found from the Anadyr River, Asia westward to Cambridge Bay, NWT, and extend into the Bering Sea and Alaska (McPhail and Lindsey 1970). In northern Canada the range of the least cisco does not extend far inland and is restricted within the Mackenzie River to Fort Simpson (McPhail and Lindsey 1970). Within BC, the least cisco is only found in the most northwest corner of the province (Scott and Crossman 1973) in Teslin, Atlin and Swan lakes all within the Yukon River drainage (Cannings and Ptolemy 1998). They are Red listed in BC (CDC 2000). The majority of information available for this species comes from Asia.

Within the western part of its range, the least cisco is abundant and inhabits large lakes and rivers and is either anadromous or resident (McPhail and Lindsey 1970). They deposit and abandon their eggs (Scott and Crossman 1973) on lake shores over sand and gravel substrates (Cannings and Ptolemy 1998). Resident populations feed on plankton and insect larvae (McPhail and Lindsey 1970). Anadromous populations of least cisco spawn over sand and gravel substrate in shallow areas of rivers during summer or fall and the eggs hatch the following spring.

Resident least ciscos can reach the age of nine years, while anadromous individuals can live up to 11 years (McPhail and Lindsey 1970). The oldest individual caught in Teslin Lake, BC was eight years of age (McPhail and Lindsey 1970).

CUTTHROAT TROUT (*ONCORHYNCHUS CLARKI*)

The cutthroat trout species is split into as many as 14 subspecies, each morphologically and geographically distinct. There are four main, widely distributed subspecies and about 10 minor, narrowly distributed subspecies (Benke 1992). Only two of the subspecies exist in BC (Scott and Crossman 1973), the coastal cutthroat trout (*Oncorhynchus clarki clarki*) and the westlope cutthroat trout (*O. c. lewisi*). The range of these two subspecies does not overlap. Coastal cutthroat trout are found between the Eel River in northern California, and Seward, south-eastern Alaska, on the west side of the Coast Range and Cascade Mountain ranges (Trotter 1989). The westslope cutthroat trout occurs inland from the Missouri basin in western Montana, to the Kootenay and Columbia River drainages in southern BC and the Yellowstone River drainage in central Wyoming (Scott and Crossman 1973).

Coastal cutthroat trout (*O. clarki clarki*)

In B.C., coastal cutthroat trout are Blue listed (CDC 2000). This subspecies exhibits four different life history strategies. Populations can either be amphidromous, potamodromous in streams, potamodromous in lakes, or stream resident (Trotter 1989). The only truly lake-dwelling strategy is potamodromous in lakes.

Amphidromous

The general life history of amphidromous cutthroat trout is similar to the Pacific salmon, however amphidromous cutthroat trout are iteroperous (multiple spawnings), and do not necessarily exhibit a strict migrational routine. Unlike Pacific salmon, these cutthroat trout may migrate to the ocean two times before becoming sexually mature (Trotter 1989). The percentage of first-return versus second-return spawners varies among watersheds (Sumner 1953, Jones 1972, 1973, 1974, 1975, 1976, Tipping 1981, Fuss 1982). Cutthroat trout may spend between one to six years within freshwater before smolting (Giger 1972). Timing of the first smolt depends on size, age, and the type of estuary the cutthroat trout is migrating into (Trotter 1989). Migration into fairly protected waters (e.g. bays) on average is at an earlier age (two to four years) and a relatively small size (Michael 1980, Tipping 1981). Larger (21 cm) and older (three to five years), cutthroat trout migrate into inhospitable waters that force them offshore (Fuss 1982). Migration to the ocean begins in late May to early June in Washington and Oregon (Trotter 1989), and late May to mid-July in Alaska (Armstrong 1971, Jones 1976). Ocean residency only lasts the summer. Cutthroat trout commonly stay within the estuary of their home stream, or venture along the shore up to 70 km, but usually do not go more than 3 km from shore (Jones 1976, Johnston 1981).

Timing of spawning varies with latitude, with more northern populations having later spawning (Trotter 1989). In BC, cutthroat trout spawn between February and May, and between April and May in Alaska (Jones 1972, 1973, 1974, 1975, 1976). Spawning takes place in small headwater and tributary streams (Scott and Crossman 1973). Redds are approximately 30 cm by 10 - 12 cm in area (Scott and Crossman 1973), and are made in pea-sized gravel in 15 - 45 cm of water in streams (Trotter 1989).

Potamodromous in rivers

River potamodromous life history populations exhibit migratory behaviours to the main stem of rivers, rather than the ocean (Dimick and Merryfield 1945, Nicholas 1978, Pfeifer 1985) to feed and grow. As these populations are usually located above barriers, they are restricted from migrating to the ocean

(Trotter 1989). Some potamodromous populations exist where there are no barriers to the ocean (Tomasson 1978). Potamodromous cutthroat trout use small tributary streams, similar to the amphidromous populations, and upstream areas of main stem rivers as spawning sites. Where the two strategies exist together, it is thought that they do not intermix (Michael 1983).

Potamodromous in lakes

Lake potamodromous populations feed and grow in lakes, and spawn in small tributary streams (Trotter 1989). Migration to spawning streams is later for lake-dwelling populations than amphidromous populations (Trotter 1989). Migration to both inlet and outlet tributary streams begins in late winter or spring. Spawning takes place when water temperatures are 5 - 6°C, in February to early June depending on the location (Trotter 1989). Sexual maturity is between three to four years of age and individuals will spawn each year thereafter (Pierce 1984).

Cutthroat trout will spend from one to three years, and occasionally four years in the tributary stream before moving to the lake (Irving 1954, Bjornn 1961, Narver 1975, Trotter 1989). Use of the lacustrine environment by cutthroat trout varies depending on the presence of other salmonids. In allopatric populations, cutthroat trout will use the whole lake (Nilsson and Northcote 1981). They can be found in the littoral and limnetic zones and forage at all depths (Nilsson and Northcote 1981) on invertebrates and fish. Shepherd (1974) suggested that the amount of cover provided, and not food availability dictates the location of cutthroat trout within a lake. Cutthroat trout were found to be associated with large mats of *Sphagnum sp.* that extended 10 m from shore and had few prey items. In situations where population size is sufficient for interaction, cutthroat trout populations in sympatry with either rainbow trout or Dolly Varden were associated with the nearshore, littoral area, while the other species inhabited offshore areas (Andrusak and Northcote 1971, Nilsson and Northcote 1981) or the bottom (Schutz and Northcote 1972). Bryant et al. (1996) found that sympatric cutthroat trout young-of-the-year used the littoral zone (< 1.5 m) of Margaret Lake, Alaska, however their use there was limited. In situations where population size is not sufficient for intense interactions between species, sympatric cutthroat trout show less of a tendency to associate with shallower areas (Pierce 1984).

Stream Resident

Movement between streams and rivers is limited in stream resident populations (Wyatt 1959, June 1981, Fuss 1982, Moore and Gregory 1988). They may be restricted to these small streams due to competition with other salmonids (Hartman and Gill 1969). Most often these fish spawn within the gravel of small headwater streams and following emergence will move to stream margins (Moore and Gregory 1988). As they grow, cutthroat trout may move farther downstream to slower water areas, although total movement is often less than 200 m (Wyatt 1959, June 1981, Fuss 1982). Stream resident cutthroat trout mature at an earlier age (two to three years, June 1981), are smaller, and live shorter lives than other cutthroat trout population types (Wyatt 1959). These fish associate with cover, such as large woody debris, and deep water (pools) within streams (Bisson et al. 1988). During winter, young-of-the-year cutthroat trout conceal themselves under clean, boulder substrate in shallow (< 0.5 m) stream margins (Griffith and Smith 1993).

Westslope cutthroat trout (*O. clarki lewisi*)

Westslope cutthroat trout inhabit waters on the west-slope of the Rocky Mountains in the Upper Kootenay and Flathead river drainages, and tributaries to the upper Columbia River upstream of Kinbasket Reservoir (BC Fisheries 2000b). There are also a few isolated populations in the Kootenay region, and the Okanagan River system at the border between the United States and Canada (BC Fisheries 2000b), and the North Thompson River (Ford et al. 1995). Within BC, west-slope cutthroat trout are Blue listed (CDC 2000). Westslope cutthroat trout occur in high and low elevation lakes and streams (Ford et al. 1995). For west-slope cutthroat trout to inhabit a lake, it must have inlet and outlet streams that have adequate gravel substrate for spawning. Lake habitat requirements are largely unknown for this species. It is thought that they will inhabit the entire lake if there is no competition for resources. Westslope cutthroat trout exhibit potamodromous (rivers and lakes) and lake or stream resident life history strategies similar to coastal cutthroat trout.

Spawning occurs in small, gravelly streams (Irving 1954, Scott and Crossman 1973) beginning in February and continuing to August (Scott and Crossman 1973, Shepard et al. 1984). Both sexes defend the redd, which the female builds (Scott and Crossman 1973). Eggs incubate for three to seven weeks (Ford et al. 1995). Newly emerged young-of-the-year will remain in the natal stream from a few months to several years before migrating to larger streams or lakes as adults (Shapley 1961, Liknes and Graham 1988). Within the stream, west-slope cutthroat trout use backwaters, stream margins and isolated pools, and move to deeper water as they grow (Moore and Gregory 1988). Preferred substrates include cobble, rubble, pebble and gravel near overhanging boulders and woody debris (Scarnecchia and Bergersen 1986, Moore and Gregory 1988). Juveniles prefer areas with a current velocity between 10 - 12.5 cm/s (Griffith 1972). Growth rate within lakes is greater than in streams (Shepard et al. 1984). Westslope cutthroat trout will move into overwintering habitat in streams, which consist of crevices in the substrate, when water temperatures reach 4 - 5°C (Bustard and Narver 1975, Liknes and Graham 1988). Often they will move to overwintering areas before moving into a lake (Ford et al. 1995). Timing of maturity ranges from two to five years of age (Ford et al. 1995).

PINK SALMON (*ONCORHYNCHUS GORBUSCHA*)

Pink salmon naturally occur along the coast of BC. Their range covers the Pacific Rim from northern Japan to northern California, and extends further north to the Mackenzie River in the Beaufort Sea and the Lena River in the East Siberian Sea (Scott and Crossman 1973, Heard 1991). Pink salmon have been introduced to Europe from Asia and to eastern Canada from western Canada (Heard 1991). Pink salmon have been reproducing naturally in the Great Lakes since 1956 (Kwain 1982). The abundance of pink salmon is highest in central and southern Alaska compared to other North American locations.

There is very little information in the literature on the lake requirements of pink salmon. There is evidence that pink salmon occupy lakes, as they were found as a prey item of cutthroat trout in Margaret Lake, Alaska (Cartwright et al. 1998). Pink salmon may simply migrate through lakes to spawning grounds as adults and to the ocean as young-of-the-year, rather than using the lake environment specifically.

In BC, migration of pink salmon to the spawning grounds begins in late July, August and September (Heard 1991). Upstream migration is limited by their inability to navigate over steep waterfalls or high-velocity sections of streams (Heard 1991). Therefore, they generally spawn close to the ocean, although pink salmon from the Skeena River, BC have been recorded to migrate up to 480 km from the river mouth (Godfrey et al. 1954). Female pink salmon choose fairly uniform areas with fairly swift current to build their redds (Heard 1991). Only when males are present do the females actually start preparing the redd. Redds are usually built within riffles on clean course gravel (Heard 1991), but also are found in a mixture of sand, gravel, and cobble substrates (Lucas 1959, Bonar et al. 1989). Water depth for spawning is usually less than 1 m deep (Scott and Crossman 1973). In BC, spawning temperatures range between 8 - 15°C (Hunter 1959, Andrew and Geen 1960), and will decrease greatly when temperatures rise over 16 - 17°C (Vernon 1958, Smirnov 1975). Female pink salmon will defend their redd after spawning (Heard 1991) until they die between 10 - 13 days later (Smirnov 1975). Eggs incubate between five to eight months (Heard 1991) and hatch between December and February with peak emergence during April or May in BC (Neave 1966). Newly emergent pink salmon generally migrate directly to the ocean at night, where they often remain in the nearshore areas for several months (Levy and Northcote 1982) before moving to the open ocean (Scott and Crossman 1973). Once in the nearshore environment, pink salmon feed primarily in the littoral zone during the daylight hours (Godin 1981). Pink salmon spend the remainder of their two year life cycle at sea after which they return to their natal stream to spawn.

CHUM SALMON (*ONCORHYNCHUS KETA*)

Chum salmon naturally occur along the coast of BC. Their range is the largest of all Pacific salmon. It extends north from the Sea of Japan to the Mackenzie River in the Beaufort Sea and the Lena River in the East Siberian Sea and south along the coast of North America to Monterey California (Scott and Crossman 1973, Salo 1991). The abundance of chum salmon is higher in North American compared to Asia (Salo 1991).

There is no information in the literature on the lake requirements of chum salmon. It is likely that chum salmon migrate through lakes to spawning grounds as adults and to the ocean as young-of-the-year.

In BC, migration to the spawning grounds is stimulated by an increase in stream runoff (Salo 1991). This usually occurs in August and September along the north coast, and is as late as October to January in the lower Fraser River (Salo 1991). Despite their large size, upstream migration of chum salmon is limited by their inability to navigate over steep areas such as fish ladders (Salo 1991). Therefore they are usually limited to reaches below large barriers (Salo 1991) often within a few miles (Mason 1974) to 100 miles (Scott and Crossman 1973) of the estuary. In the Yukon River, chum salmon spawn as far as 1200 miles from the mouth (Scott and Crossman 1973). Females select sites for spawning that are just downstream of turbulent water or in areas that have upwelling (Salo 1991). Redds are built in a mixture of small to large gravel (Sano 1959), sometimes including some silt or sand (Burner 1951), at depths often less than 0.5 m deep and in fairly swift water (Johnson et al. 1971). Eggs are usually laid in water above 4°C, so to protect the eggs from freezing (Salo 1991).

The timing of emergence from gravel is primarily dependent on water temperature, and occurs between December and February (Scott and Crossman 1973). Newly emergent chum salmon fry generally migrate directly to the ocean during the night, where they can remain in the nearshore areas for several months (Mason 1974, Levy and Northcote 1982) before moving to the open ocean (Scott and Crossman 1973). Downstream migration is later in the north (Yukon), beginning in late spring with peak migration in June and July. In the south (Fraser River), migration begins in February and continues until June (Salo 1991). The time spent in the estuary of rivers is primarily for the physiological transition to high salinity water. Chum salmon fry have been documented to exploit food from both marine and riverine environments by moving between salt and freshwater with the tides, thereby lengthening their stay within the estuary (Mason 1974). During downstream migration chum salmon fry stay near objects that provide shade and darkness, such as submerged vegetation (Salo 1991). Chum salmon can live up to four years in the ocean before returning to their natal stream to spawn.

COHO SALMON (*ONCORHYNCHUS KISUTCH*)

Coho salmon naturally occur in rivers along the coast of BC. They are evenly distributed along the west coast of North American from Point Hope, Alaska to the Sacramento River, California (Scott and Crossman 1973, Sandercock 1991). Endemic populations of coho salmon exist between the Sea of Japan and Anady River in the Bering Sea (see Sandercock 1991). The abundance of coho salmon is higher in North American compared to Asia (Salo 1991). Lake-dwelling populations of coho salmon are not common, although lake-rearing (Swain and Holtby 1989), pond-rearing (Dolloff 1993) and lake-resident (Foerster and Ricker 1953) populations do exist in BC and Alaska. Multiple introduction attempts have occurred over the past 130 years to introduce coho salmon into lakes across Canada and the northern

United States (Sandercock 1991). Coho salmon have been successfully transplanted into the Great Lakes in eastern Canada and in Cold Lake, Alberta (Scott and Crossman 1973, Sandercock 1991).

In BC, migration to the spawning grounds can begin as early as April in the Capilano River (Sandercock 1991) and Sweltzer Creek (Foerster and Ricker 1953). However, the usual timing is during September or October (Fraser et al. 1983). Spawning migration starts earlier (July/August) in northern latitudes (Sandercock 1991). Coho salmon may spawn along the whole length of small streams but do not usually venture farther than 150 miles from the mouth of large rivers (Scott and Crossman 1973). Spawning occurs between October and March in North America (Scott and Crossman 1973, Sandercock 1991). Later spawning often occurs within small, short streams (Rounsefell and Kelez 1940). The timing of upstream migration and timing of spawning are not linked. Early run coho salmon may spawn immediately within the stream or wait several months before spawning, while late run coho salmon spawn soon after getting to the spawning grounds (Sandercock 1991). The lake-resident population from Cultus Lake does not migrate to the ocean, but spawn in tributary streams to the lake (Foerster and Ricker 1953). Females select the redd sites (Sandercock 1991). Redds are usually built in shallow areas within streams with medium to small gravel (Scott and Crossman 1973).

The timing of emergence from gravel is primarily dependent on water temperature, and can occur between December and May in BC (Sandercock 1991). At 2.2°C, eggs take 137 days to hatch (Sandercock 1991). Newly emergent coho salmon young-of-the-year move to slower areas within the stream, such as side channels, near cover structures and stream banks (Tschaplinski and Hartman 1983, Bisson et al. 1988). They may migrate directly to the ocean, but more often remain within freshwater for up to two years (Foerster and Ricker 1953, Scott and Crossman 1973). The duration of freshwater residency of coho salmon is often dependent on temperature, with warmer stream temperatures leading to earlier migration to the ocean (Hartman et al. 1982, Holtby 1988). Juvenile coho salmon generally rear in streams and rivers, but also use beaver ponds (Dolloff 1993) and lakes, in Alaska (Ruggerone and Rogers 1992, Bryant et al. 1996) and BC (Foerster and Ricker 1953, Bangham and Adams 1954, Peterson 1982, Swales et al. 1987; Swain and Holtby 1989). In Mesachie Lake, BC, juvenile coho salmon were observed schooling and nonterritorial, which is not usually observed in stream environments (Swain and Holtby 1989). In Lake Chignik, Alaska, juvenile coho salmon were caught within the top 4 m of water in the nearshore littoral zone as well as the top 2 m of the offshore area (150 m from shore, Ruggerone and Rogers 1992). In Margaret Lake, Alaska, coho salmon young-of-the-year and juveniles were primarily caught in shallow areas either with rocks/silt without vegetation and with slash debris, or silt substrate with dense vegetation and slash debris (Bryant et al. 1996). Coho salmon young-of-the-year and juveniles were not often found in areas that lack cover, be it rocks, vegetation or woody debris (Bryant et al. 1996). Coho salmon juveniles may use lakes as overwintering areas (Peterson 1982, Swales et al. 1987). They will move out of streams during winter if the availability of suitable overwintering habitat within the stream environment is absent (Tschaplinski and Hartman 1983). Within streams, coho salmon young-of-the-year and juveniles select deep, slow water (Taylor 1991, Rosenfeld et al. 2000a) and cover structures (Glova 1986, Taylor 1988, McMahon and Hartman 1989, Nickelson et al. 1992) such as undercut banks and large woody debris.

Downstream migration takes place between April and August (Scott and Crossman 1973, Johnston et al. 1987). Coho salmon will spend either one year at sea and return to spawn in their natal streams after one year as precocious males (jacks), or more commonly they will spend two years at sea (Scott and Crossman 1973).

RAINBOW TROUT (*ONCORHYNCHUS MYKISS*)

The native range of rainbow trout extends from northern Baja California and north-west Mexico to the Kuskokwim River, Alaska primarily on the west side of the Rocky Mountain range (McPhail and Lindsey

1970, Scott and Crossman 1973). Rainbow trout have been introduced to lakes and rivers across North America including Hawaii, South America, New Zealand, Australia, Europe, southern Asia, Japan, and Africa (Scott and Crossman 1973). British Columbia and parts of Alberta and the Yukon Territory (McPhail and Lindsey 1970) are the only areas of Canada which support native rainbow trout. However they have been introduced in these areas as well. In BC, non-native rainbow trout have moved into the Kootenay River system (Ford et al. 1995).

There are several subspecies of *Oncorhynchus mykiss* found within its natural range. Rainbow trout also exhibit several life history strategies including the freshwater resident rainbow trout, and the anadromous steelhead (Scott and Crossman 1973). A prized land-locked population called, Kamloops trout, exist in several BC lakes including Christina, Jewel, Loon, Premier, Rosen, Okanagan, Oyama, Paul, Pinantan, Shuswap, and Williams lakes (Clemens et al. 1939, Bangham and Adams 1954, Smith 1955). This fish population was prized because of its large size (maximum size was recorded to be 36 lbs., Clemens et al. 1939). The Kamloops trout uses similar habitat as other freshwater resident rainbow trout populations, and therefore is not addressed separately. Individuals exhibiting different life history strategies can inhabit the same river system, as was observed by Neave (1949) in the Cowichan River, BC.

Freshwater resident

Rainbow trout are found in a variety of lake types, such as eutrophic and mesotrophic, but are most commonly found in deep, cold oligotrophic lakes that have inlet and outlet streams with adequate spawning habitat (Ford et al. 1995). Rainbow trout may exhibit one of two strategies depending on lake-size. In large lakes in BC, such as the Kootenay, Okanagan, Shuswap, and Quesnel (Ford et al. 1995) and Lake Washington, Washington (Beauchamp 1990), adult rainbow trout primarily feed on fish, and as a result grow large. In smaller lakes, adults feed primarily on invertebrates, and as a result are much smaller (Ford et al. 1995).

In BC, spawning takes place during the spring between mid-April to late-June in tributary streams (Hartman et al. 1962). Lindsey et al. (1959) found that rainbow trout spawning in outlet tributaries to Loon Lake, BC spawned earlier, between mid-March and June, than fish spawning in the inlets streams (late-April to July). Redds are built in clear, silt-free cold water streams (Ford et al. 1995) over fine gravel in riffles above pools (Scott and Crossman 1973) near vegetated banks (Ford et al. 1995). Rainbow trout may spawn on lake shores (Penlington 1983, Raleigh et al. 1984) over gravel substrate at depths < 1.5 m, sometimes near beds of vegetation (Penlington 1983). This evidence comes from lakes in New Zealand.

Emergence from the redd takes four to seven weeks (mid-June to mid-August, Scott and Crossman 1973, Ford et al. 1995). Newly emergent rainbow trout from lake-dwelling populations may move to the lake immediately after emergence or reside within the stream from one to three years (Lindsey et al. 1959, Northcote 1969, 1978, Scott and Crossman 1973). The duration of stay within a tributary stream may depend on the stream type, i.e. if it is the outlet or inlet of the lake (Northcote 1962). Young-of-the-year rainbow trout from outlet streams may stay a year in the stream before entering the lake, while young-of-the-year from inlet streams will move directly to the lake (Lindsey et al. 1959). The difference in stream residency may depend on water temperature, water current and direction to the lake (Northcote 1962).

Within lakes, Wurtsbaugh et al. (1975) observed young-of-the-year rainbow trout primarily between 2 - 5 m from shore, and less frequently to 10 m from the shoreline in Castle Lake, California. In general, juvenile rainbow trout in lakes inhabit nearshore environments between 3 - 6 m in depth (Ford et al. 1995). During the day rainbow trout will associate with large, cover structures such as coarse substrates (boulder, rubble and cobble) and large woody debris (Tabor and Wurtsbaugh 1991, Ford et al. 1995). If away from cover, rainbow trout will forms schools of ≥ 30 individuals in the bottom 2 m of the water column (Tabor and Wurtsbaugh 1991). At night juvenile rainbow trout will venture from cover and can be found over sand, gravel (which is avoided during the day) and cobble substrate within 10 cm of the bottom of the water column (Tabor and Wurtsbaugh 1991).

Juvenile rainbow trout from Lake Washington, Washington, were observed by Beauchamp (1990) to shift from nearshore areas (< 15 m) during winter and early spring to offshore areas (> 15 m) during late spring and summer. In Lake Tahoe, California-Nevada, rainbow trout were found between 1 - 20 m in depth associated with sand, cobble and boulder substrates (Beauchamp et al. 1994). Adult rainbow trout were caught in low abundance in the limnetic zone of Quesnel Lake, BC (Levy et al. 1991) and Babine Lake, BC (Scarsbrook and McDonald 1973, 1975). In small lakes in BC, allopatric rainbow trout use all regions of the lake (Crossman 1959, Nilsson and Northcote 1981), but while in sympatry with cutthroat trout, they were found mostly within the limnetic-surface and midwater areas of the lake (Nilsson and Northcote 1981).

Anadromous

In BC, anadromous steelhead populations are found in most large coastal streams and rivers, and also extend into the upper waters of the Fraser and Thompson Rivers (Ford et al. 1995). Steelhead exhibit a similar life cycle to Pacific salmon, although they are iteroperous. Steelhead can be distinguished from freshwater resident rainbow trout by their larger size. Juvenile steelhead use both pool and riffle habitat within the stream (Roper et al. 1994). Stream residency and timing of smoltification can take between one to four years, but more commonly between two to three years (Peven et al. 1994). In streams with slow growth rate, steelhead may remain in the stream for up to seven years. Saltwater residency can last between a few months and four years (Burgner et al. 1992). Migration to spawning grounds is variable, with both summer (May to August) and winter (December to March) runs of steelhead in BC streams (Smith 1960). All steelhead spawn between March and April, so summer run steelhead wait in freshwater for up to nine months before spawning (Smith 1960). Summer run steelhead wait in streams and sometimes lakes, while winter run steelhead spawn in coastal streams and mature in saltwater (van Dishoeck et al. 1998). Location and habitat use within lakes is unknown for steelhead trout. Within the stream, juvenile steelhead seek riffle and pool habitat in swift currents, with overhead cover and gravel, cobble, and boulder substrates (Bjornn 1971, Bjornn and Reiser 1991, Beecher et al. 1993).

SOCKEYE SALMON (*ONCORHYNCHUS NERKA*)

Sockeye salmon occur in two forms, the anadromous sockeye salmon and the freshwater lake-resident kokanee (Burgner 1991). The range of sockeye salmon, and kokanee, extends in Asia north from Hokkaido, Japan to the Anadyr River in the Berring Sea and in North America they range from the Mackenzie River in the Beaufort Sea to the Sacramento River, California (Scott and Crossman 1973, Burgner 1991). The life cycle of juvenile sockeye salmon is different from other Pacific salmon species in that they rear in lakes rather than streams, although some stream rearing populations do occur (Woods et al. 1987). Because they primarily rear in lakes, sockeye salmon were introduced into the Great Lakes in eastern Canada with varied success (Scott and Crossman 1973). Currently, there are no sockeye salmon in the Great Lakes (Cudmore-Vokey and Crossman 2000)

Anadromous

Sockeye salmon juveniles rear in many lakes within BC, ranging from two to over 1000 km from the ocean (Burgner 1991). These lakes range in size from an average of 8 to 212 m deep, 10 to 490 km^2 and up to almost 1200 m in elevation (from Burgner 1991).

In the Fraser River, BC, migration to the spawning grounds begins in July and continues to late-August or early September (Gilhousen 1960). The run timing of specific populations within the Fraser River Watershed is quite exact. For example, sockeye salmon returning to the Chilko and Stellako Rivers migrate in August while the Adams River sockeye run in September (Burgner 1991). Spawning migration is not as precise for sockeye salmon from other parts of its range. In the Skeena River drainage, sockeye have been observed moving into Lakesle Lake in early-June (Brett and Pritchard 1946a).

Female sockeye salmon select the redd site, and will defend the redd until near death (Burgner 1991). Sockeye salmon will spawn within tributary streams, streams between lakes and within lakes depending on the climate, topography and geology of the area (Burgner 1991). In general, lake spawning is of less importance within BC, except for Cultus Lake, Great Central Lake, and some lakes in the Skeena River watershed (Foskett 1947, Burgner 1991). Most of the populations within BC spawn within streams. In streams, sockeye usually spawn in water less than a metre deep (Hendry and Quinn 1997, Fukushima and Smoker 1998). Within and between lakes, sockeye salmon spawn at varying depths and substrate sizes (Foskett 1947, Kerns and Donaldson 1968, Olsen 1968). In Ilamna Lake, Alaska, sockeye salmon will spawn at 30 m on coarse sand (Olsen 1968), or in coarse rubble on a shallow beach (Kerns and Donaldson 1968). Usually, however, spawning takes place over gravel (lakes and streams, Burgner 1991). In Washington, adult sockeye salmon were observed in the nearshore zone (2 - 15 m depth) during pre-spawning (Beauchamp et al. 1995) and spawned between 9 to 16 m from the shore in < 2 m of water (Hendry and Quinn 1997). In some Skeena River lakes, sockeye were observed to spawn in shallow water to depths over 5 m deep (Foskett 1947). In the Fraser River watershed sockeye salmon spawn later in warmer region nearer the ocean (October to December: Cultus, Harrison and Pitt lake populations), and earlier in colder more distance regions (August to September: the Stuart River System).

Emergence from the spawning gravel varies among lakes. Emergence usually coincides with peak in plankton abundance allowing young-of-the-year sockeye salmon to optimize feeding within the rearing lake (Goodlad et al. 1974, Burgner 1991). In the Fraser River, emergence from gravel peaks in early to mid-May (Brannon 1987). Sockeye salmon emerge at night, and move into the rearing lake from the stream in large schools (Morton and Williams 1990), or if spawned within the lake they will move to either shallow (Burgner 1991) or deep areas (Barraclough and Robinson 1972). In some cases, such as that in the Harrison River BC, upstream migration to a rearing lake is impossible because of strong rapids or waterfalls. Harrison River sockeye salmon young-of-the-year move directly to the estuary, and essentially spend no time within freshwater (Schaefer 1951). In similar cases, young-of-the-year will rear in side channels or sloughs (Burgner 1991). Stream rearing populations are present within the Stikine River watershed, (Woods et al. 1987).

Young-of-the-year sockeye salmon utilize the limnetic zone (Heard 1965, Dawson et al. 1973, Scarsbrook and McDonald 1973, 1975, Nunnallee and Mathisen 1974) and nearshore area soon after migration into the lake in spring (Beauchamp et al. 1995). Morton and Williams (1990) found that once young-of-the-year sockeye entered Quesnel Lake, BC, they made extensive migrational movements along the shoreline, always within 5 m of shore. After five weeks (August), the young-of-the-year moved offshore to the limnetic zone (Morton and Williams 1990). In the limnetic zone, large diel vertical migrations from 80 m depths during the day to 5 m from the surface at night were observed (Morton and Williams 1990). Most commonly, sockeye spend one year (Goodlad et al. 1964, Bryant et al. 1999) rearing in lakes before migrating to the ocean, however two and three years of freshwater residency (Ricker 1941, see Burgner 1991) is possible. Juvenile sockeye salmon use either the littoral zone exclusively (Chilko and Shuswap Lakes), the limnetic zone exclusively (Cultus Lake) or both areas equally (Fraser Lake) in several BC lakes (Goodlad et al. 1974) and elsewhere (Hartman and Burgner 1972, Beauchamp et al. 1995). Most juvenile sockeye salmon use the littoral zone only in June and July (J. Hume, Fisheries and Oceans Canada, 4222 Columbia Valley Highway, Cultus Lake, BC, V2R 5B6 personal communication.). In deep, clear water, thermally stable lakes such as Babine and Shuswap lakes, juveniles are limnetic from midsummer until they smolt (J. Hume, Fisheries and Oceans Canada, 4222 Columbia Valley Highway, Cultus Lake, BC, V2R 5B6 personal communication.). Young-of-the-year and juvenile sockeye salmon inhabit the top few meters of water in Babine Lake (Johnson 1956, Scarsbrook and McDonald 1973, 1975), to 58 m in other lakes in BC (Simpson et al. 1981).

Vertical distribution of juvenile sockeye salmon can be quite variable within and among lakes throughout the year. Water clarity and depth and the stability of the thermocline can all affect juvenile sockeye salmon diel behaviour. Diel vertical migration is thought to be a predatory response, so in turbid lakes, juvenile sockeye salmon may not undergo diel vertical migrations (J. Hume, Fisheries and Oceans Canada, 4222 Columbia Valley Highway, Cultus Lake, BC, V2R 5B6 personal communication.). In Chilko Lake, which is cold and windy, the thermocline forms and dissipates in a matter of days and as a result juvenile sockeye salmon have been found offshore and nearshore, in deep and shallow water during both the day and night (J. Hume, Fisheries and Oceans Canada, 4222 Columbia Valley Highway, Cultus Lake, BC, V2R 5B6 personal communication.). In four lakes from the Fraser River watershed, Goodlad et al. (1974) found juveniles within the lower three-quarters of shallow lakes and the top half of deep lakes. Johnson (1956) caught young-of-the-year in surface waters at higher frequency during dusk then during daylight hours. Levy et al. (1991) observed juvenile sockeye salmon within Quesnel Lake, BC undergoing diel vertical migration (Levy et al. 1991). The fish alternated from 60 - 90 m during day to 10 - 25 m during the night. In Lake Ozette, Washington, juvenile sockeye salmon were found in the nearshore zone during the spring, just before migration out of the lake (Beauchamp et al. 1995).

Downstream migration takes place between April and July and is dependent on latitude, with more northern latitude populations migrating later (Burgner 1991). Brett and Pritchard (1946a) noted that ocean migration of young sockeye salmon from Lakelse Lake, in the Skeena River drainage, was completed by late-May. Migration to the ocean is also related to fish size and age, as larger older sockeye salmon will migrate earlier than younger smaller sockeye salmon (Burgner 1991). Sockeye salmon will spend either one to four years at sea, usually two to three, before returning to spawn (Burgner 1991).

Lake Resident Kokanee

Kokanee do not go to the ocean and, as a result, are much smaller than sockeye salmon. Kokanee are found in lakes where sockeye salmon rear, but they are also found in lakes that are inaccessible to the anadromous form (Burgner 1991). There are some populations within BC that are of regional importance due to their potential genetic uniqueness. These populations include kokanee from the Arctic and Thutade lakes in the upper Mackenzie River drainage, kokanee from the Queen Charlotte Islands, and kokanee from Vancouver Island, particularly the northern regions (Haas 1998). Populations of kokanee are present in many BC lakes, including Cultus Lake (Ricker 1941), Quesnel Lake (Levy et al. 1991), Babine Lake (Beacham and McDonald 1982), and the Okanagan and Columbia river drainages (J. Hume, Fisheries and Oceans, 4222 Columbia Valley Highway, Cultus Lake, BC, V2R 5B6, personal communication.).

Kokanee may spawn earlier in the fall than sockeye salmon (Scott and Crossman 1973). They spawn in shallow water (< 1 m deep) in lake tributary streams or on lake beaches over gravel or cobble substrate (Scott and Crossman 1973, Burgner 1991, Ford et al. 1995). Adults die within a few days after spawning (Ford et al. 1995). Eggs hatch by spring, with incubation time ranging from 39 days at 14.3°C, to 140 days at 4°C (see Ford et al. 1995). The newly emerged young-of-the-year will either move directly to the limnetic zone to feed on plankton, or they may reside within the littoral zone for their first year, and move out as juveniles (Ford et al. 1995). During the summer, kokanee inhabit the upper middle layer in the limnetic zone of lakes (Beauchamp et al. 1995), but move deeper with an increase in summer temperature and with the onset of winter (Scott and Crossman 1973). They are limnetic (Levy et al. 1991, Beauchamp et al. 1995), feeding primarily on plankton (Scott and Crossman 1973, Beacham and McDonald 1982). Kokanee exhibit diel vertical migration, where they are in shallower water at night and in deeper water during the day (Finnell and Reed 1969, Narver 1970, Levy 1991). Sexual maturity is usually at age four (Scott and Crossman 1973, Beauchamp et al. 1995). Kokanee young-of-the-year have an upper lethal temperature limit of 22°C (Black 1953).

CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*)

Chinook salmon naturally occur, and are most abundant, along the coast of BC (Healey 1991). Their range extends in Asia north from Hokkaido, Japan to the Anadyr River in the Bering Sea. In North America they range from north of Katzebue Sound, Alaska south to the San Joaquin River, California (Scott and Crossman 1973, Healey 1991). Chinook salmon are typically in large river systems (Healey 1991). Chinook salmon have been introduced into large lakes and river systems throughout Europe, eastern Canada and Central and South America (Scott and Crossman 1973).

There are two main forms of chinook salmon, stream-type and ocean-type, as well as many intermediates. Stream-type chinook salmon spend a larger portion of their life within freshwater, both before migration to the ocean (one to three years) and during migration to spawning grounds (several months, Healey 1991). Ocean-type chinook salmon spend less than a year rearing in freshwater and will enter freshwater only days or weeks before spawning (Healey 1991). Stream-type chinook salmon are more frequent in the northern range (above the 56), while the ocean-type are the dominant type below 56 (Healey 1991).

In BC, migration to the spawning grounds begins in July and continues to November (Scott and Crossman 1973). Chinook salmon will spawn within a hundred metres of the estuary or up to 600 miles upstream in the Fraser River and 1200 miles in the Yukon River (Scott and Crossman 1973). Female chinook salmon select the redd site. Redds are built on gravel substrates (Scott and Crossman 1973), primarily in large rivers (Healey 1991) and at depths less than 1.2 m at the head of riffles (Chapman 1943). Chinook salmon have also been recorded to spawn in the main stem of the Columbia River in 5 m of water (Chapman 1943). Freshwater populations of chinook salmon will spawn on gravel shoals of lake shores or within small tributaries to the lake (Scott and Crossman 1973). Chinook salmon spawn in May or June in the most northern part of the range, between July to September in BC and as late as November or January in the most southern locations (Healey 1991).

It is common for newly emergent ocean-type chinook salmon young-of-the-year to migrate directly to the ocean where they remain in the estuary or nearshore areas for several months to reach smolt size (see Healey 1991) before moving to the open ocean. Downstream migration to the estuary and ocean by juvenile chinook salmon occurs during April and May in the Fraser River, BC (Levy and Northcote 1982). Stream-type chinook salmon will reside within freshwater for up to two years (Healey 1983), with some individuals never going to the ocean (Scott and Crossman 1973). In streams and rivers, juvenile chinook salmon associate with cobble and boulder substrates, in fairly fast flowing water < 1.0 m (Porter and Rosenfeld 1999). Introduced populations of juvenile chinook salmon in a New Zealand lake were found in the shallow (< 5 m depth) limnetic zone, and younger chinook salmon (young-of-the-year) were found in deeper water (Graynoth 1999). Some juvenile chinook salmon were caught in the surface water in some BC lakes (Simpson et al. 1981).

Chinook salmon live between one (precocious jacks) to five years (ocean-type) in the ocean before returning to their natal stream to spawn, however two to three years is more common (Scott and Crossman 1973).

PYGMY WHITEFISH (*PROSOPIUM COULTERI*)

The pygmy whitefish occurs in several isolated and relict locations across North America (Haas 1998). The largest range of pygmy whitefish occurs across BC into western Montana and Washington states within the Columbia, Fraser, Skeena, Peace and Liard River drainages, as well as the Teslin and Alsek Rivers systems in BC and the Yukon (Scott and Crossman 1973). They may be absent from the Nass, Stikine and Taku rivers (McPhail and Carveth 1993a). There are other isolated populations of pygmy whitefish in south-western Alaska in Bristol Bay and the Alaska Peninsula, and in Lake Superior (Scott and Crossman 1973). A unique form of pygmy whitefish, the giant pygmy whitefish, exists within two separate lakes, McLeese Lake and Tyhee (Maclure) Lake in the Fraser and Buckley River drainages respectively (Cannings and Ptolemy 1998). It is thought that this larger form of the pygmy whitefish (up to twice as large) evolved separately within the two lakes and therefore has not yet been recognized as a separate species (Cannings and Ptolemy 1998).

Pygmy whitefish

In BC, pygmy whitefish inhabit mountain lakes and clear or silted rivers (Scott and Crossman 1973). They typically are found in water deeper than 7 m, but may use shallow areas as well (Scott and Crossman 1973). In Lake Superior, this species is more a deep-water fish and is normally found between 18 - 88 m of water (Dryer 1966).

There is little information on the spawning biology of pygmy whitefish. Spawning is thought to take place in shallow areas in streams and lakes over coarse gravel substrate where eggs are deposited and abandoned by the adults (Scott and Crossman 1973). Spawning occurs during October and November in BC (McCart 1965), and slightly later in Montana and Lake Superior (December to January, Scott and Crossman 1973). Pygmy whitefish can live up to nine years of age in some BC lakes (Scott and Crossman 1973).

Giant pygmy whitefish

Giant pygmy whitefish are only found within two small lakes in BC, McLeese Lake in the Fraser River drainage and Tyhee (Maclure) Lake in the Buckley River drainage (Cannings and Ptolemy 1998). Lack of competition with other whitefish species is thought to be the cause of the divergence in size within the pygmy whitefish populations (McCart 1965). The giant pygmy whitefish is found at depths between 4 - 20 m. Spawning behaviour and ecology is not known for this form, however it is suspected to be similar to pygmy whitefish which spawn within lakes during November or December.

ROUND WHITEFISH (*PROSOPIUM CYLINDRACEUM*)

Round whitefish are distributed across most of northern and eastern Canada as well as north-eastern Asia (Scott and Crossman 1973). Round whitefish can be found from the New England states to northern New Brunswick, Labrador and Ungava west along southern Quebec and Ontario and into all of the Great Lakes (Scott and Crossman 1973, Cudmore-Vokey and Crossman 2000). They are found in isolated locations in Connecticut, and along the Ontario-Manitoba border (Scott and Crossman 1973). From northern Manitoba to Alaska, round whitefish distribution is more continuous. In BC, round whitefish are found only in the northern portion of the province (Scott and Crossman 1973).

Round whitefish are a bottom feeding species. They are typically found in deep water lakes throughout their southern range and shallower lakes in the north (Dryer 1966, Scott and Crossman 1973). Even in the deep Great Lakes, round whitefish usually do not venture deeper than 45 m (Dryer 1966), however exceptions to this rule have been recorded. A single round whitefish was caught at 219 m in Lake

Superior in 1959 (Scott and Crossman 1973). In the northern and eastern parts of its range, such as Quebec and New Brunswick, round whitefish may inhabit rivers and brackish waters.

Spawning takes place primarily in the shallows of lakes or at river mouths, and only occasionally occurs in rivers (Scott and Crossman 1973). Timing of spawning varies with latitude, with northern populations spawning earlier than southern populations. Populations in the Great Lakes, and New Hampshire have been reported to spawn during November or December (Mraz 1964, Normandeau 1969) while populations from lakes in the Northwest Territories spawn during October and November (Harper 1948). Spawning usually takes place over gravel, rubble, boulder and rock substrate in 0.1 - 2 m of water (Normandeau 1969), but can be as deep as 16 m (Scott and Crossman 1973). Others have reported spawning in shallow areas of lakes between < 1 - 14 m of water (Normandeau 1969) over silt to boulder substrate (Bryan and Kato 1972). The eggs are deposited and abandoned by the adults (Scott and Crossman 1973).

Hatching time of round whitefish is approximately 140 days at 2.2°C, with peak hatching occurring in April (Hart 1930, Normandeau 1969). The data presented in Rawson (1951) suggests that young-of-the-year and juvenile round whitefish occupy shallower waters (< 10 m deep) while older fish are found in water between 15 - 35 m deep in Great Slave Lake, NWT. Sexual maturity in round whitefish is within their fourth or fifth years (Normandeau 1969). Maximum age and size of round whitefish is 13 years and 561 mm respectively (Scott and Crossman 1973).

MOUNTAIN WHITEFISH (*PROSOPIUM WILLIAMSONI*)

Mountain whitefish are present in all the major river drainages in BC, except the Yukon River drainage and Vancouver Island and Queen Charlotte Islands (Haas 1998). Their range is exclusively in western North America from Wyoming, Nevada, and Montana to Alberta (Milk and Saskatchewan Rivers) and northern BC (Scott and Crossman 1973, Haas 1998). In BC, two different forms of mountain whitefish, the pinocchio and normal forms, occur in Kootenay Lake (McPhail and Carveth 1993a). The morphological difference is attributed to differences in trophic level or genetics (McPhail and Carveth 1993a).

Single form populations

Typically these fish are bottom feeders (Ricker 1952), however in lakes that lack an adequate bottom fauna they will feed throughout the water column (McPhail and Lindsey 1970). They live in lakes and clear or silty rivers (McPhail and Lindsey 1970) and seem to prefer large over small streams (Scott and Crossman 1973, Ford et al. 1995). In streams in the Nazko River drainage, BC, juvenile and adult mountain whitefish were most often found in deep, fast water over gravel and cobble substrates (Porter and Rosenfeld 1999). In the Skeena drainage, mountain whitefish were found in large, deep lakes as well as small, shallow lakes (Godfrey 1955). They were most abundant in eutrophic-type lakes that house a healthy supply of benthic organisms (Godfrey 1955). In BC, they have been caught at low numbers in the limnetic zone of Quesnel Lake (Levy et al. 1991), Okanagan Lake (McHugh 1939), and Bear Lake (Simpson et al. 1981). Typically, mountain whitefish do not inhabit waters deeper than 20 m and will most likely be found in water 4 - 6 m deep (Scott and Crossman 1973).

In BC, spawning begins in November and continues to January (McHugh 1939, McPhail and Lindsey 1970). In Montana, spawning began in October (Brown 1952). Mountain whitefish congregate into small groups (2 - 5 individuals) at night in shallow water (< 1 m, to 6 - 20 m) in anticipation of spawning (Brown 1952, Hagen 1970). Eggs are laid on gravel and rubble substrate either on shallow lake shores, or in tributary streams and abandoned by the adults (Brown 1951, McPhail and Lindsey 1970, Scott and Crossman 1973). Hatching occurs after 36 days at 16.6°C (Brown 1952). Young that were spawned in rivers, move to the lake by the end of summer. Young spawned in lakes move to deeper offshore areas from the spawning areas when water temperatures increase (Ford et al. 1995). Juveniles and adults use aquatic vegetation and submerged cover as refuge.

The maximum age that has been recorded is 18 years (McPhail and Lindsey 1970). Mountain whitefish reach sexual maturity between three to four years of age.

Two form population

Two forms of mountain whitefish occur in Kootenay Lake, BC, the normal form and the pinocchio form. These two forms exist either due to trophic differences or genetic differences (McPhail and Carveth 1993a). The two forms spawn at different times in the lake, beginning in late October and finishing in early February. Spawning within Kootenay Lake is done in darkness (McPhail and Lindsey 1970).

ATLANTIC SALMON (*SALMO SALAR*)

As their name would suggest, Atlantic salmon naturally occur on the Atlantic coast. Their range extends from the Connecticut River north along the coast to Ungava, across to Greenland, Iceland and Portugal (Scott and Crossman 1973). Atlantic salmon were first transplanted to the north Pacific Coast in 1905 (MacCrimmon and Gots 1979). That and subsequent transplantation attempts were unsuccessful (Wing et al. 1992). Since the early 1970's numerous aquaculture operations of Atlantic salmon have been established on the Pacific Coast. Salmon aquaculture expanded rapidly in BC in 1985 (Heal 1985), and in 1971 in the Puget Sound (Mighell 1981). Capture of escaped Atlantic salmon in the Alaska salmon commercial fisheries was first noticed in the late 1987 (Wing et al. 1992). Since then there have been several large scale, and many more undocumented escapes of Atlantic salmon in BC waters. It is believed that Atlantic salmon are naturally reproducing in Vancouver Island rivers, thereby providing evidence that colonization is possible (Volpe et al. 2000). Gross (1998) stated that 94% of adult Atlantic salmon on the Atlantic coast are "domestic stock", meaning that the aquaculture populations may almost constitute their own species. On both the Atlantic and Pacific coasts, domestic Atlantic salmon threaten native salmon species (Gross 1998). Hybridization between Atlantic and Pacific salmon is not a threat, as hybrids are not viable (see Wing et al. 1992). However transmission of nonindigenous disease and parasites is a concern (Wing et al. 1992).

Many lakes that have Atlantic salmon aquaculture operations also may support free-swimming Atlantic salmon populations (J. Volpe, Department of Biology and Centre for Environmental Health, University of Victoria, BC, personal communication.), but there is no direct evidence of lake-dwelling populations in BC (G. Haas, BC Fisheries, 2204 Main Mall, Vancouver, BC, V6T 1Z4, personal communication.). Most of the information for spawning, migration and freshwater habitat requirements come from the Atlantic coast of Canada. The following information is summarized from the extensive review by Bradbury et al. (1999).

Timing of upstream spawning migration varies between May to early September. Spawning occurs between early-October and mid-November. Female Atlantic salmon select gravelly riffles to make their redds (Scott and Crossman 1973, Scott and Scott 1988). Atlantic salmon are interparous, so some adults may either remain in fresh or estuarine water for the winter, or migrate back to the ocean after spawning (Scott and Scott 1988). Eggs incubate over the winter and hatch between mid-April and mid-June. Atlantic salmon typically rear in freshwater anywhere between two to five years. Migration to the ocean takes place in May and June, and ocean residency lasts between one to three years.

When in freshwater, anadromous Atlantic salmon are most often found in streams, but there are populations that use estuarine and lacustrine habitat (Chadwick and Green 1985, Matthews et al. 1997).

Movement into lakes will occur within the first year of life (Leggett and Power 1969, Erkinaro and Gibson 1997), usually in the spring and early summer (Erkinaro and Gibson 1997). Juvenile Atlantic salmon may use lakes for overwintering, because lakes offer more favourable environmental conditions than streams (Northcote 1978), or because lakes have higher food availability (Northcote 1978, Erkinaro and Gibson 1997). Hutchings (1986) suggested that reduced energy requirements in a lentic versus lotic environment, along with reduced competition for food and space, are further reasons why juvenile Atlantic salmon use lacustrine habitat.

Within the lake, younger juvenile anadromous Atlantic salmon inhabit the littoral zone and as they grow older they move to the limnetic and deeper profundal areas (Bradbury et al. 1999). Juvenile Atlantic salmon in the littoral zone can be found over rocky areas with or without submergent and emergent vegetation.

BROWN TROUT (*SALMO TRUTTA*)

Brown trout were introduced to North America from Europe and western Asia (Scott and Crossman 1973). Presently, brown trout occur on Vancouver Island, in the Okanagan River drainage and the Arrow Lakes region (BC Fisheries 2000a). Most of the information available comes from Europe. This review comes primarily from Bradbury et al. (1999) and Scott and Crossman (1973).

Anadromous or lake-dwelling populations have become established in streams and lakes where brown trout have been introduced (Scott and Crossman 1973, Bradbury et al. 1999). Often spawning takes place in streams over gravel substrate (Scott and Scott 1988), or rocky shorelines of lakes (Scott and Crossman 1973). For all types of populations, spawning begins in fall and early winter (Scott and Crossman 1973). In BC, spawning can last until January (Carl 1938). Females build a redd within the substrate, where the eggs are laid and covered with more substrate (Scott and Crossman 1973). Young-of-the-year brown trout remain within the streams for a few years before migrating to a lake to mature (Bradbury et al. 1999). All population types (anadromous, stream resident) of brown trout migrate to lakes to overwinter (Bradbury et al. 1999), although, young-of-the-year brown trout that remain within the stream conceal themselves under boulder and cobble substrate in shallow (< 0.5 m) river margins (Griffith and Smith 1993). Growth rate within the lake environment is higher than within the stream, which is a possible reason why juvenile brown trout migrate to lakes (Bradbury et al. 1999). Within the lake, larger brown trout occupy slightly deeper and benthic regions than smaller brown trout which remain in the shallow littoral area. Smaller brown trout use boulders and rocks as cover within the littoral zone. Brown trout are carnivorous (Scott and Crossman 1973). Larger brown trout within lakes shift habitat to follow food resources, and will move into the limnetic zone to feed during the summer (Bradbury et al. 1999). During the winter, some individuals inhabit shallow, littoral areas of lakes, while other individuals inhabit deeper, offshore areas (Bradbury et al. 1999). In the spring and summer, deep water brown trout move back into shallow littoral areas. Optimal temperature range of brown trout is between 18.3 - 23.9°C (Scott and Crossman 1973). Sexual maturity is reached by age two to six years, depending on location (Bradbury et al. 1999). Maximum age of brown trout is around 10 years of age, however individuals up to 13 years of age have been collected (Scott and Crossman 1973, Bradbury et al. 1999).

BULL TROUT (*SALVELINUS CONFLUENTUS*)

Bull trout are a char species endemic to western North America (Haas and McPhail 1991). In BC, the bull trout is an interior species found on the eastern slopes of the Cascade and Coast Mountains (McPhail and Baxter 1996). It is often mistaken for Dolly Varden, *S. malma*, which are very similar in appearance but have a more coastal range (McPhail and Lindsey 1970). Cavender (1978) described the bull trout as a distinct species. In BC, bull trout are Blue listed (CDC 2000).

The range of bull trout has shrunk in recent years due to population extinction, especially in the southern portions of its range (Carl 1985, Rode 1988, Goetz 1989, Brown 1992). In BC, declining population size has been noticed in the Columbia River drainage and the lower Fraser Valley (Hagen and Baxter 1992, Hagen 1993a, b). Recently, COSWEIC listed the bull trout as a vulnerable species in Canada (Campbell 1998). The current distribution of bull trout extends from the southern portion of the Yukon territory and the south-western corner of NWT, into parts of western Alberta, south to northern California and southern Nevada (Miller and Morton 1952, Scott and Crossman 1973, McPhail and Baxter 1996). This species is absent from coastal waters in BC except for the Fraser and Squamish River systems (McPhail and Baxter 1996), and from the Okanagan, Similkameen and Kettle River systems (Cannings and Ptolemy 1998). Bull trout is a cold water species found in high gradient, unproductive waters (Baxter 1997). Typically, bull trout do not inhabit waters that are warmer than 15°C (Cannings and Ptolemy 1998).

Bull trout exhibit four life history strategies: (1) stream resident, (2) fluvial-adfluvial, (3) lacustrine-adfluvial, and (4) anadromous (Cannings and Ptolemy 1998). Individuals exhibiting either resident or migratory life history strategies can exist within a single system (Cannings and Ptolemy 1998).

Spawning takes place in flowing water (Heimer 1965, McPhail and Murray 1979, Oliver 1979, Leggett 1980, Goetz 1989, Pratt 1992), presumably in smaller rivers and tributary streams (McPhail and Baxter 1996). Spawning within the main stem Liard River may take place (Stewart et al. 1982), but time spent within main stem rivers is thought to be low (McPhail and Baxter 1996). Spawning occurs during September and October (Cannings and Ptolemy 1998), with little variation between northern (mid-August and September) and southern (mid-September to late-October) populations (see McPhail and Baxter 1996). Temperatures ≤ 9°C are thought to trigger spawning activity in bull trout (McPhail and Murray 1979, Weaver and White 1985), while temperatures ≤ 5°C are thought to cease spawning (Allan 1987). Spawning takes place over small gravel, in slow moving water, in low gradient areas, near cover structures such as, undercut banks, log jams, and overhanging vegetation (McPhail and Murray 1979, Oliver 1979, Allan 1980, Leggett 1980, Allan 1987, Fraley and Shepard 1989). In larger rivers, redds are built downstream of aggraded areas (Graham et al. 1981), near ground water sources (Heimer 1965). Bull trout will spawn more than once, but not necessarily every year after maturation (Cannings and Ptolemy 1998).

Incubation of eggs depends on water temperature. Optimal incubation temperature is thought to be between 2 - 4°C (McPhail and Murray 1979). Young-of-the-year emerge from gravel during spring between April and May (Ratliff 1992) and stay closely associated with the bottom (McPhail and Baxter 1996). In rivers, they use shallow (< 0.5 m), low velocity areas that have ample cobble, boulder substrates, root-wads and woody debris as overhead cover (Baxter 1997). Often these areas are in side channels and pools (McPhail and Murray 1979, Pratt 1992, Allan 1987). Baxter (1997) found that juveniles use similar cover structures as young-of-the-year, but prefer root-wads. Juveniles associate with undercut banks, woody debris, and coarse substrate (Allan 1987). Habitat use changes between seasons and time of day. Juveniles inhabit pool habitat during the summer, and run habitat during the fall (McPhail and Baxter 1996). During the day, juvenile bull trout in streams prefer cobble and boulder substrate in slightly shallower water than at night when they prefer open, deeper and faster areas over silt substrate (Baxter and McPhail 1997). Most juveniles remain in streams for up to four years (McPhail and Murray 1979, Shepard et al. 1984, Nakano et al. 1992, Pratt 1992, Sexauer 1994) before migrating to the main stem, lake or the ocean (depending on life history strategy).

Stream resident

Stream resident individuals are often separated from other populations by physical barriers (McPhail and Baxter 1996). Resident bull trout inhabit deep pools and use cover (McPhail and Baxter 1996). Resident individuals are smaller in size than other populations (McPhail and Baxter 1996), and sexual maturity is reached at an earlier age (one to two years, Robinson and McCart 1974, Craig and Bruce 1982) and smaller size than the migratory forms (Cannings and Ptolemy 1998).

Fluvial-adfluvial

Fluvial-adfluvial individuals remain in large, main stem rivers for their adult lives, except when they migrate to small tributary systems to spawn (Craig and Bruce 1982, Allan 1980, Boag 1987, Fraley and Shepard 1989, Hildebrand 1991). The opposite migration, from tributary stream to main stem, was observed in the Liard River system during the fall (Stewart et al. 1982, Craig and Bruce 1982), and may have been linked to timing of spawning (Stewart et al. 1982). In their southern and central range, adult bull trout are more constrained by water temperature so are found primarily in large pools of rivers, or at the mouths of tributary streams (Shepard et al. 1984, Buckman et al. 1992, Hagen and Baxter 1992). In the north, bull trout are not temperature constrained and as a result are found in both small and large streams and rivers (McLeod et al. 1979, Irvine and Rowland 1979, Craig and Bruce 1982). Individuals from fluvial populations obtain larger sizes than resident populations (Baxter 1995).

Lacustrine-adfluvial

Lacustrine populations of bull trout are most common in the central range of this species (McPhail and Baxter 1996). Adult bull trout are found in large, oligotrophic, high altitude lakes. Spawning takes place in tributaries streams to the lake (Carl et al. 1989, Cannings and Ptolemy 1998), and spawning migrations can be very long (Fraley and Shepard 1989). Over the course of a year, bull trout use the entire lake. Adult bull trout feed in the littoral zone during the fall and spring, and move into deep water during the summer (Goetz 1989). Adult bull trout in lakes can grow quite large, up to 7 kg and to an age of 10 - 11 years (McPhail and Murray 1979).

Anadromous

This life history strategy is the least studied (McPhail and Baxter 1996). Anadromous individuals of bull trout are suspected to exist within the Squamish River, BC, however this has not yet been confirmed (Cannings and Ptolemy 1998).

BROOK TROUT (*SALVELINUS FONTINALIS*)

Brook trout have been introduced into lakes and rivers throughout BC, including the Columbia, Peace, Skeena, and Okanagan river drainages and Vancouver Island (Ford et al. 1995, BC Fisheries 2000a). Brook trout are endemic to North America, although they have been introduced around the world due to their appeal as a sport fish (Scott and Crossman 1973). Their native range extends from eastern Manitoba to Labrador and Newfoundland south to Georgia and the upper Mississippi River. They are typically a cold water species (Dymond and Scott 1941, Scott and Crossman 1973, Wurtsbaugh et al. 1975, Meisner 1990) inhabiting cool, clear lakes and streams (Dymond and Scott 1941, Scott and Crossman 1973, Lacasse and Magnan 1992, Ford et al. 1995), that are ≤ 20°C (Morrow 1980). It has been suggested that with global warming, increases in water temperature may limit the available habitat for brook trout within the southern portion of their range (Meisner 1990). Brook trout exhibit three life history strategies which include a stream resident form, a lake to stream freshwater form, and an anadromous form (Power 1980). Presumably all forms exist in British Columbia (BC Fisheries 2000a). The biology of anadromous and resident populations appears to be similar (Bradbury et al. 1999). Timing of sexual maturity and reproduction are the main characteristics that differ among the life history strategies (Ford et al. 1995).

Spawning takes place during the late summer and fall (Scott and Crossman 1973, Ford et al. 1995) in water between 3 - 9°C (Morrow 1980, Quinn 1995). In anadromous or lacustrine populations, migration to spawning grounds commences between August to October (Ford et al. 1995). In the north, spawning takes place during August, while in the south, spawning continues to December (Morrow 1980). Spawning usually is in gravelly headwater or tributary streams, or in lakes over shallow, gravel areas that have upwelling currents (Saunders and Power 1970, Scott and Crossman 1973, Fraser 1985, Snucins et al. 1992, Ford et al. 1995, Quinn 1995), or are located near inflow streams (Quinn 1995). Spawning in lakes is often in shallow water < 2 m deep, but has been recorded at 7 m deep (Wurtsbaugh et al. 1975, Fraser 1985, Quinn 1995, Bradbury et al. 1999). Females often clear the redd of silt and debris before spawning (Ford et al. 1995). In lakes, fine substrates tend to deposit over the redd once the eggs have been laid (Snucins et al. 1992). Eggs usually emerge by spring, often after the first snow melt of the season (Fraser 1985, Snucins et al. 1992). In Castle Lake, California, Wurtsbaugh et al. (1975) recorded that during the summer young-of-the-year brook trout used shallow areas that had cold water springs rather than moving to deeper water. Juvenile and young-of-the-year brook trout used areas with extensive overhead vegetation and submergent debris in the shallow areas of Castle Lake. Brook trout young-of-the-year and juveniles use shallow littoral areas < 2 m deep. Brook trout use rocks, aquatic vegetation, woody debris and overhanging logs as cover (Bradbury et al. 1999). During the summer, brook trout move to cooler, deeper waters. During the winter, they move to shallower water (< 5 m deep) in ponds, and may associate with gravel, rubble and boulder substrates (O'Connell and Dempson 1996, Bradbury et al. 1999).

Brook trout reach sexual maturity in lakes at age three (Saunders and Power 1970). Brook trout reach different maximum ages depending on which environment they inhabit. In lakes, brook trout reach a maximum age of seven years, while they reach only four years in streams (Saunders and Power 1970).

DOLLY VARDEN (*SALVELINUS MALMA*)

In BC, Dolly Varden are found in all coastal waters, including Vancouver Island and the Queen Charlotte Islands (Scott and Crossman 1973). Dolly Varden are also found farther inland in the Skeena and Fraser River drainages, as well as headwater streams of the Liard and Peace Rivers (Scott and Crossman 1973, Haas 1998). Elsewhere, Dolly Varden are found along the coast south to the McCloud River in California, inland to western Montana and north to Seward, Alaska and into Asia to the Anadyr River, Russia, and the Yalu River, Korea (Scott and Crossman 1973). Many coastal populations in BC are in severe decline, possibly due to habitat destruction and overfishing (Haas 1998). For this reason, Dolly Varden have been Blue listed in BC (CDC 2000). Dolly Varden exhibit both anadromous and freshwater resident life history strategies (Scott and Crossman 1973). However, spawning behaviour and maturation are similar in both types.

Spawning begins in the fall, with spawners returning to their natal stream starting in September and ending in early-November (Delacy and Morton 1942, Scott and Crossman 1973). Males are aggressive on the spawning grounds and defend a redd dug by a female (Scott and Crossman 1973). Spawning takes place in rivers during the day, over medium to large gravel, in moderate velocity water, at water temperature near 8°C. Adults will spawn each year, sometimes up to four consecutive years (Armstrong 1974).

Sexual maturity is reached between three to six years of age, with males usually maturing a year earlier than females (Scott and Crossman 1973). Maximum age of Dolly Varden is approximately 10 - 12 years (Bjornn 1961). A 20 year old Dolly Varden was caught in California (Scott and Crossman 1973)

Resident

In freshwater, Dolly Varden are primarily stream resident (Bustard and Royea 1995), but they are also found in BC lakes (Ricker 1941, Andrusak and Northcote 1971). Juveniles will reside in freshwater from a few months to four years before migrating to a lake (Scott and Crossman 1973). When in sympatry with cutthroat trout, Dolly Varden are found primarily at the bottom or midwater areas of shallow water (Andrusak and Northcote 1971, Schutz and Northcote 1972, Andrew et al. 1992).

Anadromous

Anadromous Dolly Varden juveniles typically reside in freshwater for three to four years before migrating to the ocean (Scott and Crossman 1973). Juveniles may rear in rivers, streams or beaver ponds (Dolloff 1993). Research done in southeastern Alaska by Armstrong (1965, 1974) found that anadromous Dolly Varden from lake-stream populations (spawned in streams connected to a lake), or non-lake populations (spawned in streams not connected to a lake) exhibit a range of migrational behaviours. Individuals from lake-stream populations, leave lakes in spring and summer to migrate to the ocean for the summer, and return to the lake to overwinter (Armstrong 1974), while other individuals migrate to non-lake streams (Armstrong 1965). The opposite is true for individuals from non-lake populations. These individuals enter the ocean in spring and fall at ages between two to four years and move between non-lake and lake-stream systems, often in search of lakes to overwinter (Armstrong 1974). Once mature, Dolly Varden from non-lake populations will migrate back to their natal streams to spawn. In general, movement into lakes are made by immature individuals, individuals that spawned in other streams, and individuals ready to spawn in tributaries to the lake (Logan 1962, Marriott 1965, Blackett 1968). Usually, movement into lakes by anadromous Dolly Varden is for overwintering (DeLacy and Morton 1942, Nelson 1959, Logan 1962, Revet 1962, Meehan 1966, Marriott 1967). However, overwintering in large rivers also occurs (Armstrong 1974). Spawning migration into rivers from the ocean begins in May and continues to December (DeLacy and Morton 1942, Scott and Crossman1973).

LAKE TROUT (*SALVELINUS NAMAYCUSH*)

Lake trout are endemic to North America (McPhail and Lindsey 1970). In BC, lake trout are present in the upper Fraser, Peace, and Liard river drainages in the interior and coastal drainages from the Skeena River north into the Yukon (McPhail and Lindsey 1970, Scott and Crossman 1973). Elsewhere, lake trout are found from Bristol Bay, Alaska, through the Yukon River drainage and Mackenzie River drainage, across Canada to watersheds draining into the Hudson Bay, the Great Lakes, St. Lawrence River to Labrador (Scott and Crossman 1973). Typically, lake trout inhabit large, deep, clear, cold lakes (Rawson 1951, Loftus 1957, Dryer 1966, Johnson et al. 1977, Martin and Oliver 1980), where they are limnetic (Levy et al. 1991). Lake trout have been caught at depths between 20 - 80 m in Lake Superior (Loftus 1957, Dryer 1966), and throughout Great Slave Lake, NWT to depths of 225 m (Rawson 1951).

Spawning takes place between July and November in Ontario (Martin 1956, Loftus 1957), and roughly the same period across Canada (Scott and Crossman 1973). Spawning possibly takes place during October in BC (Ford et al. 1995). There are stream spawning populations in Lake Superior that mature at smaller sizes and spawn over large boulders and coarse gravel in eddies (Loftus 1957). Otherwise, spawning and the whole life cycle of lake trout occurs within lakes (McPhail and Lindsey 1970, Scott and Crossman 1973, Ford et al. 1995). Depth of spawning is dependent on lake size. In larger lakes, spawning depth is deeper, presumably because of deeper shoals and greater wave action (Martin 1956). Spawning in small lakes is often in water < 5 m deep (Martin 1956). For example in Lake Superior, lake trout were reported to have spawned between 125 - 185 m (Thibodeau and Kelso 1990). In other Ontario lakes, lake trout spawn in shallow water ranging from 0.15 - 15 m (Martin 1956, Thibodeau and Kelso 1990). Lake trout primarily spawn over course substrate such as rubble and gravel (Martin 1956, Ford et al. 1995), and sometimes sand (Thibodeau and Kelso 1990), but never mud or detritus (Martin 1956). Usually, the male will clear mud and sand from the spawning area before spawning takes place, although he does not build a nest (McPhail and Lindsey 1970). Spawning takes place at night at 10 - 12.8°C (Martin 1956), where eggs are scattered over the substrate (McPhail and Lindsey 1970, Scott and

Crossman 1973). Eggs incubate between 15 - 21 weeks at 0.3 - 1.0°C (Martin 1956). Once the young-of-the-year emerge (February to June), they will remain on the spawning grounds from a few weeks to a few months feeding on invertebrates (Scott and Crossman 1973, Ford et al. 1995). McPhail and Lindsey (1970) stated that young lake trout remain in shallow water for several years before moving into deeper water. In some Ontario lakes, Martin (1956) reported young-of-the-year leaving the spawning grounds by mid-May. Young-of-the-year and juvenile lake trout move into deeper water, where they switch to feeding primarily on fish (Ford et al. 1995). Juvenile and adult lake trout were found between 1 - 13 m of water in Lac La Martre, NWT (Libosvarsky 1970). Adult lake trout are piscivorous and usually the top predator where they exist (Martin and Olver 1980). Invertebrates and vertebrates, along with plant material, are fed upon to a lesser degree (Scott and Crossman 1973, Martin and Olver 1980).

Lake trout mature between the ages of five to eleven years in Great Slave Lake, NWT (Kennedy 1954), and ages seven to eight in Lake Superior (Loftus 1957). Mature females usually do not spawn in successive years (McPhail and Lindsey 1970). Lake trout can live an exceptionally long time. Average life span is estimated to be between 25 - 30 years (Scott and Crossman 1973, Ford et al. 1995). This species is known to hybridize with brook trout (Martin and Baldwin 1960)

INCONNU (*STENODUS LEUCICHTHYS*)

Distribution of inconnu in BC is limited to Teslin Lake in the Yukon River drainage and Muskwa River in the Liard River drainage (McPhail and Carveth 1993a). In the rest of its range, inconnu occurs from the Kuskokwin River in the Bering Sea, Alaska to the Anderson River near Cape Bathurst in the Northwest Territory (Scott and Crossman 1973). Inconnu occur in parts of the Yukon River, Mackenzie River and into the Slave River, south to Fort Smith and Fort Nelson in the Liard drainage. Inconnu range across Arctic drainages of northern Asia to the White Sea.

Inconnu are primarily anadromous (along coastal regions), but inland lake-resident populations exist (Scott and Crossman 1973). Both anadromous and lake resident populations migrate to spawning grounds in river in late summer and early fall. Work that has been done in Great Slave Lake, NWT suggests that inconnu move upstream into tributary rivers to spawn and move back downstream after spawning. Young inconnu may remain up to two years in the stream environment before migrating back to the lake.

Adult inconnu are found primarily in water < 10 m deep along shores, with infrequent catches in water 75 m deep in Great Slave Lake (Rawson 1951). They were found in fairly high numbers in the shallow, heavily silted water off the southern shore of Great Slave Lake, near the outflow to the Mackenzie River (Fuller 1955). Inconnu in Great Slave Lake mature sexually between seven to ten years of age and live up to 11 years (Scott and Crossman 1973). In comparison, individuals from Siberian populations can live up to 21 years.

ARCTIC GRAYLING (*THYMALLUS ARCTICUS*)

In BC, arctic grayling are found in the Mackenzie, Yukon, Stikine, Alsek and Taku river drainages, primarily in the headwaters and upstream of major barriers (Haas 1998). Arctic grayling have a holarctic distribution. They are found from Hudson Bay to Alaska and the Bering Sea to the Ob River to northern Mongolia and the Upper Yalu River (Scott and Crossman 1973). This species has been introduced to various locations in the United States, Alberta, and Saskatchewan (Scott and Crossman 1973, Haas 1998). Arctic grayling in the Belly River, Alberta and the Flathead River, BC were established from the natural expansion of introduced populations in Montana (Scott and Crossman 1973, Haas 1998). Many populations of arctic grayling are in decline or have gone extinct throughout BC and other areas of its range, including the population from the Flathead River (Haas 1998). Habitat degradation and overfishing are thought to be the main causes of the decline (Northcote 1995). The population of arctic grayling residing above the W.A.C. Bennett Dam in the Williston Reservoir system, BC is Red listed because of a large decline in population density over the past 20 years (Cannings and Ptolemy 1998). This species seems to be highly adapted to local environmental conditions, so perturbations made by humans can be detrimental (McPhail and Lindsey 1970)

The typical habitat of arctic grayling is in clear water of large cold rivers, smaller rocky streams and lakes (Scott and Crossman 1973). They avoid turbid waters, but will inhabit milky, glacial streams. In rivers they are most often found in pools, just downstream of riffles (Ford et al. 1995). In pools, they are associated with small boulders and gravel. Arctic grayling are planktivorous feeders (Schmidt and O'Brien 1982).

Spawning occurs immediately after ice break-up in small tributary streams of large rivers (Scott and Crossman 1973) and lakes (Clark 1994). In BC, this happens between mid-May and mid-June (Ford et al. 1995), and elsewhere between April and June when temperatures are between 7 - 10°C (Scott and Crossman 1973, Craig and Poulin 1975, Beauchamp 1990). Spawning takes place over gravel and rock in small tributary streams, but when no appropriate spawning habitat is available, spawning will occur over gravel and rock or sometimes over muddy vegetated areas in pools of large rivers (Scott and Crossman 1973). Males are territorial, however no redd or nest is made during spawning. Adults return to large rivers or lakes after spawning and provide no parental care for the eggs. Eggs hatch relatively quickly (eight to 32 days) depending on water temperature during incubation (15.5 - 5.8°C, Kratt and Smith 1977, Krueger 1981, Kaya 1989), and young-of-the-year grow rapidly during their first year of life (Harper 1948, Kratt and Smith 1979, Liknes and Gould 1987, Kindschi and Barrows 1990). Young-of-the-year inhabit pools and side channels to depths of 30 - 50 cm and velocities ≤ 0.8 m/s (Townsend 1976, Stuart and Chislett 1979, Hubert et al. 1985), over cobble, boulder and sand substrates (Ford et al. 1995).

Juveniles may overwinter in lakes with adults (Ford et al. 1995), however in Fielding Lake, Alaska, juvenile arctic grayling were caught along the beach during June (Clark 1994). Usually, juveniles stay within the nursery tributary streams during summer (Ford et al. 1995). Arctic grayling in the tributaries form territories, with the larger fish inhabiting the optimal locations (Craig and Poulin 1975, Kratt and Smith 1979, Stuart and Chislett 1979). Decreasing temperatures trigger movement downstream to overwintering areas in main stem rivers or lakes (Ford et al. 1995).

In Great Slave Lake, NWT, arctic grayling were found along rocky shores near river mouths in shallow areas < 10 m deep (Rawson 1951). In rivers, adults can be found in water < 30 cm and velocities 0.21 - 0.8 m/s (Hubert et al. 1985, Liknes and Gould 1987, Ford et al. 1995). Age of sexual maturity varies slightly from south to north (Ford et al. 1995). In the Yukon and NWT, sexual maturity is reached as late as seven to nine years of age, while in northern BC, sexual maturity is reached between ages three to six (Rawson 1950, Bishop 1971, Scott and Crossman 1973, Hubert et al. 1985, Liknes and Gould 1987, Northcote 1995). After maturity, spawning may occur each year (Scott and Crossman 1973). Maximum age is reached near 11 - 12 years.

TROUT-PERCHES (*PERCOPSIDAE*)

TROUT-PERCH (*PERCOPSIS OMISCOMAYCUS*)

In BC, trout-perch are limited to the Liard and Peace river drainages (Lindsey 1956). The rest of the range of trout-perch extends from northern BC, to the Mackenzie River delta at Aklavik, NWT, (McAllister 1961), west along coastal Alaska, then east to the Hudson River and south to the Mississippi Valley (Lindsey 1956).

Trout-perch are a lake dwelling species, but can also be found in turbid rivers and small, boggy tributaries throughout its range (Dymond and Scott 1941, Scott and Crossman 1973). This species is often found in shallow areas of muddy flowing water in the northern extent of its range (Lindsey 1956, McAllister 1961, Scott and Crossman 1973). Typically, trout-perch inhabit deep waters of lakes during the day and shallower waters at night (Emery 1973, Scott and Crossman 1973, Morrow 1980). Trout-perch school near the bottom of lakes at or below the thermocline during the day (Emery 1973) and summer (Dadswell 1972). At night, this species moves into shallower water between 2 - 15 m deep and associates with the bottom, but not necessarily in schools (Emery 1973). In Ontario and Quebec, trout-perch were caught most commonly between 5 - 15 m of water, but were caught to 20 m and over beaches at night when water temperatures were < 21°C (Dadswell 1972). In Lake Superior, trout-perch were collected to > 70 m depths (Dryer 1966), and between 10 - 61 m in other lakes (Morrow 1980) They use weeds or boulder substrate as cover and feed over sand or mud bottoms (Emery 1973). In streams, trout-perch hide in long, deep pools under undercut banks, roots and woody debris during the day, and move to shallower water at night to feed (Morrow 1980).

Spawning takes place between late-May and mid-August depending on location (Lawler 1954, Magnuson and Smith 1963, McPhail and Lindsey 1970, Scott and Crossman 1973). Spawning typically takes place in streams, although there are some reports of spawning on lake shores (Langlois 1954, Magnuson and Smith 1963, Scott and Crossman 1973, Morrow 1980). In streams, trout-perch spawn over rocky substrate in shallow areas of small streams (Lawler 1954, Scott and Crossman 1973). Eggs hatch within 20 days (Lawler 1954). Three weeks after hatching, young-of-the-year trout-perch move into deeper water (Magnuson and Smith 1963). Kinney (1950) reported trout-perch spawning at age one, although others have concluded sexual maturity is not until age two for males and age three for females (Lawler 1954, Magnuson and Smith 1963, Morrow 1980). The spawning population consists of a mixture of one, two, three and four years olds, because a small percentage of individuals spawn twice (Kinney 1950, Lawler 1954, Magnuson and Smith 1963). Females are larger than males, and live to age four, while males live to age three (Trautman 1957, Priegel 1962, Magnuson and Smith 1963).

CODS (*GADIDAE*)

BURBOT (*LOTA LOTA*)

In BC, burbot occur in lakes and large rivers throughout the province, except along the coast and islands (Scott and Crossman 1973, Ford et al. 1995). Burbot populations from the lower Kootenay River and lower Columbia River are Red listed within BC (CDC 2000). Burbot are distributed across northern Eurasia and North America (McPhail and Lindsey 1970). In Canada and the United States, burbot are found from the Columbia River north to the Bering Sea and the Arctic Ocean, east to Labrador and south again to Missouri (McPhail and Lindsey 1970). Burbot are unique as they are the only freshwater cod species (Scott and Crossman 1973).

Burbot typically inhabit deep waters of lakes (Rawson 1951, Dryer 1966), but in northern Canada they also inhabit cool, large rivers (Scott and Crossman 1973). In Great Slave Lake, NWT, burbot were the only species of fish to increase in number with increasing depth to 100 m (Rawson 1951). In Columbia Lake, BC, which has an average depth of 2.9 m and does not form a summer thermocline, burbot were observed there year round (Taylor 2001). During the summer burbot are restricted to deeper offshore areas near the hypolimnion where optimum and maximum temperatures are 15 - 18°C and 23°C respectively (Scott and Crossman 1973). Lawler (1963) found burbot on the bottom in the deep areas of Heming Lake, Manitoba, in November and December. As temperatures start to cool in the fall and winter, burbot move into shallower littoral areas (Lawler 1963, Scott and Crossman 1973, Bruce 1974, Morrow 1980, Kirillov 1988a and b, Carl 1992, Edsall et al. 1993, Ford et al. 1995).

Burbot are one of the few freshwater species to spawn during midwinter (McPhail and Lindsey 1970), often under ice (Ford et al. 1995). Burbot spawn in shallow areas of either lakes (Mansfield et al. 1983, Ghan and Sprules 1991) or rivers (McPhail and Lindsey 1970, Arndt and Hutchinson 2000). In rivers they spawn over clean sand, gravel or cobble and rubble substrate (McCrimmon and Devitt 1954, Sorokin 1971, Scott and Crossman 1973, Bruce 1974, Morrow 1980, Mansfield et al. 1983, Breeser et al. 1988, Ford et al. 1995). In lakes, burbot spawn over clear areas with limited silt and detritus accumulation, in water typically 0.3 - 3.0 m deep (McCrimmon and Devitt 1954, McPhail and Lindsey 1970, Sorokin 1971, Scott and Crossman 1973, Morrow 1980, Mansfield et al. 1983, Ford et al. 1995). Spawning in deeper water has been observed (Scott and Crossman 1973). Spawning activity has been observed during late-January (Hewson 1955) continuing to March (McCrimmon and Devitt 1954, Lawler 1963, Faber 1970, Sorokin 1971, Scott and Crossman 1973, 1974, Morrow 1980, Breeser et al. 1988, Ford et al. 1995). In Lake Winnipeg, capture of mature adults was more common in the nearshore area than the offshore area, although mature adults were captured in low numbers offshore (Hewson 1955). The semi-buoyant eggs are broadcast into the water column just above the substrate and after a few days become demersal and settle into the interstices of the substrate (Sorokin 1971, Morrow 1980, Ford et al. 1995). Optimal egg incubation temperature ranges from 2 - 6°C (Taylor 2001). Egg survival was found to be highest at 3°C, and lowest (all eggs died) at temperatures > 6°C. In the laboratory, Taylor (2001) found that eggs hatched within 28 days at 5°C, and 38 days at 3°C, while Scott and Crossman (1973) reported hatching after 30 days at about 12°C.

Larvae are limnetic (Clady 1976, Mansfield et al. 1983, Ghan and Sprules 1991, Ryder and Pesendorfer 1992), but by early summer, at a size range of 21 - 50 mm, larvae shift to a primarily benthic form (Ryder and Pesendorfer 1992, McPhail 1997a. These newly benthic young-of-the-year usually associate with gravel, cobble or rubble substrate in the shallow (0.5 - 3.0 m) littoral regions of lakes (Lawler 1963, Faber 1970, Mansfield et al. 1983, Ryder and Pesendorfer 1992, Ford et al. 1995). Larvae have been collected at depths to 13.5 m (Mansfield et al. 1983). Juvenile burbot were found in the Nazko River, BC, in shallow, fast flowing water over gravel and cobble substrates (Porter and Rosenfeld 1999). They are less active during the day than at night where they have been observed hiding under rocks and debris (Lawler 1963, Boag 1989, Ryder and Pesendorfer 1992). Juvenile burbot feed on benthic invertebrates and use essentially the same habitat as young-of-the-year (McPhail 1997a). In streams, young burbot associate with undercut banks, submerged logs and vegetation preferably near rocky areas, but will use sandy areas (Scott and Crossman 1973, Hanson and Qadri 1980). In lakes, juvenile and adult burbot associate with gravel, cobble and rubble substrate (Scott and Crossman 1973, Morrow 1980, Ford et al. 1995, Taylor 2001). During the summer in deep offshore areas of lakes, adult burbot seek dark areas, such as under boulders or amongst aquatic vegetation, to rest and hide (Edsall et al 1993). Adult burbot are mainly piscivorous (McCrimmon and Devitt 1954, Lawler 1963, Bruce 1974, Parsons 1975, Ryan 1980), but are known to eat benthic invertebrates during the summer and fall (Lawler 1963, Bailey 1972, Ryan 1980).

Sexual maturity of burbot may be delayed in colder water (Hewson 1955). Female burbot may mature at an earlier age (two years) and smaller size then males (Hewson 1955). Typically across their range, burbot sexually mature between two to eight years of age (McCrimmon and Devitt 1954, Scott and Crossman 1973, Ryan 1980, Ford et al. 1995). In Canada, they reach a maximum age of 10 - 15 years (Scott and Crossman 1973).

STICKLEBACKS (*GASTEROSTEIDAE*)

BROOK STICKLEBACK (*CULAEA INCONSTANS*)

In BC, brook stickleback are found only in the Peace River area along the border between Alberta and BC (Scott and Crossman 1973). Their distribution ranges across the northern portion of the continent from Nova Scotia and New York west to the Hay River region of the Great Slave Lake, and south to Montana.

Brook stickleback inhabit clear, cold waters in small streams, spring-fed ponds, and swampy areas and stagnant waters of larger lakes (Scott and Crossman 1973). Brook stickleback are often associated with densely vegetated areas, and also have a tolerance for saline waters (Miller and Thomas 1957, Nelson 1968a, Scott and Crossman 1973).

Brook stickleback spawn during late-April to July, depending on temperature (Jacobs 1948, Winn 1960, Scott and Crossman 1973). Spawning occurs when water temperatures reach between 8 - 19°C (Jacobs 1948, Winn 1960). Males build a nest, often on reed stems or grasses, close to the bottom near the substrate in shallow water (Winn 1960, Thomas 1962) of lakes and presumably streams. The nest is made of dead organic matter and algae that is bound together by kidney secretions (Winn 1960, Thomas 1962). More than one female will lay eggs in a single nest (Winn 1960, Thomas 1962). Eggs hatch within eight to nine days at 18.3°C (Breder and Rosen 1966). Males defend the nest until the young leave (Scott and Crossman 1973). There may be some migration between lake and stream habitats (Winn 1960, Lamsa 1963).

THREESPINE STICKLEBACK (*GASTEROSTEUS ACULEATUS*)

The threespine stickleback has an interesting history and taxonomy. It is a highly adaptive species, and is found in several forms (anadromous, freshwater resident, giant, limnetic/benthic,) across its range in BC (Schluter and McPhail 1992). The species in general has a very large distribution. The threespine stickleback is found along the Pacific coast of North America and Asia, in many parts of Europe, southern Greenland, and the coastal waters from Baffin Island, Hudson Bay to Chesapeake Bay (Scott and Crossman 1973). In BC, this species is found on all the coastal islands, in small streams and rivers along the coast and in the Fraser River to Kawkawa Lake near Hope.

In general, freshwater resident threespine sticklebacks are found in shallow bays of lakes within 10 m from shore (Brett and Pritchard 1946b, Jakobsen et al. 1988), or slow streams (McPhail and Lindsey 1970). Threespine sticklebacks were abundant in the limnetic zone of lakes in BC (Simpson et al. 1981). They associate with vegetation (Brett and Pritchard 1946b, Jakobsen et al. 1988), but this association is not as strong as with other stickleback species (McPhail and Lindsey 1970).

Anadromous threespine sticklebacks differ from freshwater resident populations in that they have a slightly different morphology (more plated, Morrow 1980), they can spawn in saline or freshwater (McPhail 1969), they spawn in areas dense with vegetation, and they reach sexual maturity after one year (Narver 1969). Young-of-the-year anadromous threespine stickleback leave their natal stream or estuary and move into salt water, often staying near shore within seaweed beds until fall when they move farther from shore (Morrow 1980). Some anadromous individuals were found in the ocean near the surface pelagic zone 800 km from shore (Clemens and Wilby 1961, McPhail and Lindsey 1970).

Freshwater resident threespine sticklebacks spawn in the spring and summer, between April and early-July in BC (McPhail and Lindsey 1970, Larson 1976). Different than other stickleback species, the males build their nests on the bottom substrate of lakes in more open areas, but still associated with vegetation (McPhail and Lindsey 1970, Scott and Crossman 1973). The nest is built on sand substrate, in shallow water in the littoral zone (McPhail and Lindsey 1970, Scott and Crossman 1973, Larson 1976). The nest is built from fragments of aquatic vegetation and organic debris, and held together by kidney secretions (McPhail and Lindsey 1970, Scott and Crossman 1973). The male attracts females to the nest using a complex courtship dance (McPhail and Lindsey 1970). Once the female swims through the nest and deposits the adhesive egg, the male will then immediately chase her away and fertilizes the eggs within the nest (McPhail and Lindsey 1970, Scott and Crossman 1973). More than one female will lay eggs within a single nest (McPhail and Lindsey 1970). The male threespine stickleback will fan the eggs using his pectoral fin until they hatch. Eggs hatch within seven days at 19°C (Breder and Rosen 1966). The males are aggressive throughout the breeding season (Huntingford 1977), and will guard the young sticklebacks until they are able to leave the nest (Scott and Crossman 1973). Juvenile and adult threespine stickleback remain in the nearshore area, often associated with vegetation (Jakobsen et al. 1988). In Alaska, sexual maturity was recorded to be between one to two years of age, with maximum life expectancy of three years (Greenbank and Nelson 1959).

Giant Black Stickleback

Recent work on the taxonomy of giant black stickleback at the University of British Columbia, shows that the giant black stickleback may be separate from other *Gasterosteus* populations on the west coast of BC (Cannings and Ptolemy 1998). This unique stickleback is thought to have evolved after the last glaciation (Gach and Reimchen 1989). The morphology of the giant black stickleback is different from other sticklebacks. Giant black sticklebacks are larger, black in colour, and more streamlined (Moodie and Reimchen 1973). The large size of this stickleback form is thought to be an adaptive response to predation by cutthroat trout and common loons (*Gavia immer*) (Moodie 1972b). Giant black sticklebacks are found in Drizzle and Mayer lakes on the east side of Graham Island, the northern Queen Charlotte Island, and Misty Lake on northern Vancouver Island (Cannings and Ptolemy 1998). They may also be present in two other lakes on the central, northern mainland coast (Cannings and Ptolemy 1998). All these lakes are low elevation lakes. Giant black sticklebacks have never been captured in streams (Moodie 1972a, Cannings and Ptolemy 1998). Giant black sticklebacks are considered a vulnerable species by COSEWIC, and are Red listed in BC (Cannings and Ptolemy 1998).

Giant black sticklebacks spawn in spring and summer (April-July) in shallow areas over gravel or sand substrate, on a gentle gradient, near rock or moss shelter (Moodie 1972a, Cannings and Ptolemy 1998). The males build a nest, in which the females lay their eggs (Moodie 1972a). Females produce up to 257 eggs per clutch, however the number of clutches within a season is unknown (Moodie 1984). Males will complete about five nesting cycles with a breeding season, which include building the nest, mating with females, allowing the eggs to hatch and, at least eight days of care of the young-of-the-year (Moodie 1972a, Cannings and Ptolemy 1998). Eggs are usually laid within 1.2 m of cover, and after hatching, the young-of-the-year remain near the cover (Moodie 1972a). Eggs hatch within nine days of fertilization (Moodie 1972a). In Mayer Lake, spawners die after breeding, like other stickleback species (Moodie 1984). In Drizzle Lake, it seems that many adults survive after breeding and live to breed the next year (Reimchen 1992). Sexual maturity is at age two (Moodie 1972a, Scott and Crossman 1973). Giant black sticklebacks from Drizzle Lake are known to reach eight years of age, which is exceptionally long for the family Gasterosteidae (Reimchen 1992).

Limnetic-Benthic Species Pairs

There are five lakes (formally six) along the coast of BC where the limnetic-benthic threespine stickleback species pairs exist. They occur in Enos Lake, Vancouver Island, and Paxton, Priest, Balkwill and Emily lakes on Texada Island (Haas 1998). They were present in Hadley Lake on Lasqueti Island, however this population was extirpated after the deliberate introduction of an exotic species. The rest of the species pair populations are Red listed (CDC 2000). It is likely that populations within each lake have independently undergone rapid post-glacial speciation thereby making each species pair unique (distinct from one another) (McPhail 1984, 1992, 1993a, 1994, Schluter 1996, Taylor et al. 1996). The two forms exist due to trophic competition and character displacement (McPhail 1992, 1993a). Low levels of hybridization occur within each lake, however the distinct phenotypes are maintained (McPhail 1993a).

The two forms of threespine stickleback are morphologically and ecologically distinct from one another (McPhail 1992). The limnetic form is found primarily in the limnetic zone of lakes and feed on plankton (Larson 1976, McPhail 1988, McPhail 1989). During the summer, large groups of the limnetic form associate with the surface waters offshore, often near terrestrial cover such as trees and docks (Larson 1976, Cannings and Ptolemy 1998). Thermal stratification occurs in these small lakes during the summer, causing the limnetic sticklebacks to remain above the thermocline (2 - 5 m) (Larson 1976, McPhail 1988). When water levels are abnormally low, the limnetic form will move into the littoral zone and associate with aquatic vegetation (Larson 1976). During the winter, the limnetic form moves into deeper water and associates with bottom substrates (Larson 1976). Morphologically, the limnetic form is adapted for planktonic feeding (Larson 1976), as it has a long slender body, and is often less aggressive than the benthic form (Larson 1976, Cannings and Ptolemy 1998). The benthic form is found primarily near the bottom in the littoral zone of lakes associated with mud and submerged aquatic plants or logs, especially during the summer (Larson 1976, McPhail 1989), and can be found throughout the lake during the winter (McPhail 1989). Benthic sticklebacks feed on benthic invertebrates (Larson 1976, McPhail 1989). They have a large, robust body, and are more aggressive than the limnetic form (Larson 1976, Cannings and Ptolemy 1998).

NINESPINE STICKLEBACK (*PUNGITIUS PUNGITIUS*)

Typically a northern species, the ninespine stickleback has a limited distribution in BC. Ninespine sticklebacks are reported only in the north-east corner of the province near Old Fort Nelson in the Fort Nelson River (McPhail and Lindsey 1970, Scott and Crossman 1973, Cannings and Ptolemy 1998, Haas 1998). During two recent surveys in that area, no ninespine sticklebacks were collected (Haas 1998). They have recently been collected for the first time further south in the Petitot River in that region. In BC, ninespine sticklebacks are Red listed (CDC 2000). Elsewhere in North America, ninespine sticklebacks found in fresh and saline waters along the coast from the Aleutian Islands in Alaska to the Mackenzie River delta (McPhail and Lindsey 1970). Ninespine sticklebacks are present in the Arctic Archipelago, and inland throughout the NWT, across the prairie provinces to Labrador and Nova Scotia (McPhail and Lindsey 1970, Scott and Crossman 1973). They are not present in southern Alberta and Saskatchewan (Scott and Crossman 1973). This species is also found down the Pacific Coast of Kamchatka and Japan, as well as the Arctic and Baltic drainages (Haas 1998).

Ninespine sticklebacks have a fairly high tolerance for saline water (Nelson 1968a). Ninespine sticklebacks associate with densely vegetated areas (McPhail and Lindsey 1970, Dadswell 1972), but are also found in open water areas offshore (Nelson 1968b, Dadswell 1972, Emery 1973, Scott and Crossman 1973), and to great depths (Dryer 1966). During the day and dusk when feeding, ninespine sticklebacks from an Ontario lake were found within 50 cm of the bottom in water ranging between 10 - 15 m deep (Emery 1973). At night during the summer, ninespine stickleback were sometimes observed swimming in open water offshore, in 10 - 15 m deep water, but between 2 - 5 m of the surface (Emery 1973). In Ontario and Quebec, ninespine sticklebacks were caught between 5 - 20 m of water, and sometimes at 40 m and 1 m (Dadswell 1972). In Lake Superior, this species was caught between 76 - 89 m depths (Dryer 1966, Scott and Crossman 1973). In lakes that have thermal stratification, ninespine sticklebacks are often found in warmer, deep areas in early-spring and late-fall (Griswold and Smith 1973). During spring turnover, when water temperatures are the same throughout the lake, ninespine sticklebacks can be found at all depths (Griswold and Smith 1973).

Males build a nest on the stems of plants, usually off the bottom substrates most often in shallow water (Reckahn 1970, Scott and Crossman 1973). Spawning between depths of 5 - 40 m has also been observed (Nelson 1968b, Becker 1983). The nest is made up of fragments of algae and other aquatic vegetation held together by kidney secretions (McKenzie and Keenleyside 1970, McPhail and Lindsey 1970, Reckahn 1970, Scott and Crossman 1973, Wootton 1976, Morrow 1980). McKenzie and Keenleyside (1970) observed nests built in shallow areas (< 0.8 m) under and between rocks on lake shores. The male entices a female to swim through and deposit eggs within the nest (Scott and Crossman 1973). More than one female will deposit eggs in a single nest (Scott and Crossman 1973). The males will aerate the eggs within the nest by fanning his pectoral fin over the nest entrance (Scott and Crossman 1973, Wootton 1976, Burgess 1978, Scott and Scott 1988). Males guard the nest until the eggs have hatched and the young are free swimming (Scott and Crossman 1973). In densely vegetated areas, the male will construct an area above the nest built from nest materials where the young-of-the-year rest (McPhail and Lindsey 1970, Wootton 1976, Keenleyside 1979, Morrow 1980). Sexual maturity of lake populations is thought to be within the first year, and life span is about three-and-a-half years (Jones and Hynes 1950). Ninespine sticklebacks from the St. Lawrence River system may live to just over 1 year (Coad and Power 1973). Individuals from this species have been found to reach five years of age (Wootton 1984). Because sexual maturity is within the first year, there is no real juvenile stage for this species.

SCULPINS (*COTTIDAE*)

COASTRANGE SCULPIN (*COTTUS ALEUTICUS*)

Coastrange sculpin are widespread in coastal streams on the Pacific coast from San Luis Obispo County, central California, to Kiska Island, Alaska (Scott and Crossman 1973, Lee et a*l.* 1980). In BC, they are found in streams and inland lakes in the Fraser, Skeena, Nass and Stikine river drainages, as well as in small coastal streams and on Vancouver Island and the Queen Charlotte Islands (Scott and Crossman 1973). Although *Cottus* is primarily a freshwater genus, coastrange sculpins can withstand brackish waters (Scott and Crossman 1973, Brown et al. 1995). They have also been found to use estuarine habitat during part of their life cycle in the Eel River, California (Brown et al. 1995).

Spawning takes place during spring from February to mid-June (Scott and Crossman 1973), but February to mid-April in Lake Washington, Washington state (Ikusemiju 1975). Adhesive eggs are deposited over gravel in riffles of small coastal or tributary streams (Ricker 1960, Scott and Crossman 1973). The egg mass is guarded by the males, who may spawn with more than one female (Scott and Crossman 1973). Larvae are not present until July or August (McLarney 1968). Larvae are planktonic (McLarney 1968), residing within the top 6 m from the surface, for the first 32 and 35 days before taking up benthic living (Heard 1965, Scott and Crossman 1973, Ikusemiju 1975). Once benthic, the coastrange sculpin prefers lotic environments (Scott and Crossman).

Coastrange sculpin are often found in sympatry with prickly sculpin in coastal streams and rivers from Alaska to southeastern California (Lee et al. 1980). In several small coastal streams on Vancouver Island, sympatric coastrange sculpin inhabit riffles, while prickly sculpin inhabit deeper pools (Mason and Machidori 1976). In larger rivers both niche partitioning (White and Harvey 1999) and niche overlap (Brown et al. 1995) have been documented. In the Smith River, California, coastrange sculpin inhabit areas < 1 m deep with a velocity > 5 cm/s, while prickly sculpin inhabit deeper, slower water (White and Harvey 1999). Very little habitat segregation was noticed between the two species in the Eel River, California (Brown et al. 1995).

In lakes, coastrange sculpin generally inhabit the benthic zone in deep-water (Ricker 1941), or sandy or muddy nearshore areas (Scott and Crossman 1973) in quiet water near lake shores and tributary mouths (McPhail and Lindsey 1970). They have been reported to move into shallower water of lakeshores to feed on recently spawned sockeye salmon eggs (Foote and Brown 1997). Coastrange sculpin feed primarily at night on invertebrates, salmonid eggs and young-of-the-year (Pritchard 1936, Shapovalov and Taft 1954, McPhail and Lindsey 1970, Foote and Brown 1997). Diel vertical migration has been observed in Lake Washington (Ikusemiju 1975). Coastrange sculpin were found near the bottom, no less than 27 m in depth during the day, and in the limnetic zone between 5 - 27 m during the night (Ikusemiju 1975). Maximum age of coastrange sculpin is estimated to be four years (Scott and Crossman 1973).

Cultus Pygmy sculpin

In 1937, Ricker discovered a dwarf form of coastrange sculpin in Cultus Lake, BC (Ricker 1960). This form, called the Cultus pygmy sculpin (*Cottus* sp.), is endemic to Canada, and is found only in Cultus Lake (Coffie 1998). It is Red listed by the CDC in BC (CDC 2000). A similar subspecies is found in Lake Washington, Washington state (Lee et al. 1980, McPhail and Lindsey 1986). The Cultus pygmy sculpin is considerably smaller than the coastrange sculpin. It resembles the larval form of coastrange sculpin, and is approximately 50 mm in length by ages three to four years (Ricker 1960, Larson and Brown 1975, Cannings 1993). The Cultus pygmy sculpin is found in the limnetic zone and is restricted to deeper water (Larson and Brown 1975, Coffie 1998). Spawning is assumed to occur during May and July in deep water, when individuals are three years of age (Ricker 1960). Virtually no work has been done on this subspecies, however the population status is assumed to be stable (Coffie 1998).

PRICKLY SCULPIN (*COTTUS ASPER*)

The distribution of prickly sculpin ranges along the Pacific coast of North America from Seward, Alaska, south to Ventura River, California (McPhail and Lindsey 1970, Scott and Crossman 1973). In BC, prickly sculpin are found in coastal rivers and lakes and in the Nass, Stikine, Skeena, Dean, Fraser and Columbia rivers (Scott and Crossman 1973). It is also found on Vancouver Island and the Queen Charlotte Islands (Scott and Crossman 1973). There is only one location east of the Continental Divide, in the upper Peace River, where this species resides (McPhail and Lindsey 1970). They are often found in sympatry with coastrange sculpin in coastal streams and rivers from Alaska to southeastern California (Lee et al. 1980).

Prickly sculpin inhabit a range of habitats, all of which are characteristic of slow flowing water. Prickly sculpin are most commonly freshwater residents, found in pools of clear coastal streams and rivers, turbid rivers, and lake shores, but some catadromous populations may exist (Northcote 1954, Krejsa 1967a,b, McLarney 1968, McPhail and Lindsey 1970). In several small coastal streams on Vancouver Island, sympatric coastrange sculpin occupied riffles, while prickly sculpin inhabited deeper pools (Mason and Machidori 1976). In larger systems, such as the Smith River, California, prickly sculpin inhabit areas > 7 m deep with a velocity ≤ 5 cm/s, while coastrange sculpin inhabit shallower, faster water (White and Harvey 1999). No inter-specific habitat segregation was observed in the Eel River, California (Brown et al. 1995). In the Nazko River, BC, prickly sculpin were most often found in shallow, fast flowing water over gravel and cobble substrate (Porter and Rosenfeld 1999). The prickly sculpin is abundant in the nearshore environment in some lakes (Ricker 1941, Patten and Rodman 1969), but are found in deep water in Lake Washington, Washington (Ikusemiju 1975). In Clear Lake, California, prickly sculpin are found in deep water (> 10 m) during the day, and within the top 10 m during the night (Broadway and Moyle 1978).

In BC, spawning occurs from February in the southern portion of the range, to late-July in the northern portion (Krejsa 1967b, Scott and Crossman 1973). Spawning water temperatures range between 8 - 13°C (Krejsa 1967b). Males select sites in streams that are slow flowing and have boulders, cobbles and a flat rock bottom (Scott and Crossman 1973). The nests consist of the rough underside of rocks. Males will court up to ten females that lay adhesive eggs in the nest. The males defend the nest once the female has left. Eggs hatch within 15 - 16 days if temperatures are 12°C. Larvae may form schools, but remain planktonic (McLarney 1968) for 30 - 35 days before transforming into a benthic form (Northcote and Hartman 1959, Broadway and Moyle 1978). Benthic young-of-the-year feed on benthic invertebrates and sometimes fish (Ricker 1952). Limnetic young-of-the-year were caught in surface tows (≤ 1.5 m) in Clear Lake, California (Broadway and Moyle 1978). Juveniles and adults were captured over mud, sand, to boulder substrates and bedrock. Upper lethal temperature limit for prickly sculpin was reported as 24°C (Black 1953).

MOTTLED SCULPIN (*COTTUS BAIRDI*)

The mottled sculpin has a discontinuous distribution across Canada. In BC, its range is confined to a portion of the Columbia River drainage, including parts of the Similkameen, Kettle, Kootenay, and Flathead rivers, as well as Kootenay and the Arrow Lakes (for exact locations see Cannings and Ptolemy 1998). In the western portion of its range, the mottled sculpin is also found in Utah, Montana, Idaho and Washington states (Scott and Crossman 1973). Its widest range is in eastern North America where it is located from Georgia and Alabama to Labrador and the Great Lakes. Because of its limited distribution, the mottled sculpin is considered a vulnerable species in both BC and Alberta by COSEWIC (Campbell 1998), and a vulnerable species in BC by the CDC (CDC 2000).

In BC, mottled sculpin are primarily found in small, cool streams, large rivers and their tributaries, and clear warm water muddy bottomed weedy mountain lakes (Cannings and Ptolemy 1998). In the Flathead River, mottled sculpin were associated with slow flowing areas that were not heavily sedimented but had stones (Hughes and Peden 1984, Peden and Hughes 1984b), and in the Columbia River they were found in the main stem (Peden et al. 1989). They are also common in small tributaries of the Similkameen River drainage (Peden et al. 1989).

Most of the research on behaviour and spawning of mottled sculpin comes from populations in the eastern portion of its range. Timing of spawning is usually in spring during April or mid-May, but can vary depending on location (Scott and Crossman 1973). Males select the spawning site, which is usually under rocks and logs in the shallow littoral zone of lakes (Savage 1963, Scott and Crossman 1973, Lyons 1987). Females deposit adhesive eggs to the underside of the nest object and leave the males to depend the nest (Scott and Crossman 1973). Age of first spawning was estimated by Koster (1936, from Scott and Crossman 1973) as being at three years of age, but sometimes they mature at age two. Koster suggested that spawning occurs at 10°C and hatching happens approximately a month after spawning, but depends largely on water temperature.

The mottled sculpin is a benthic species (Scott and Crossman 1973). Young-of-the-year mottled sculpin were observed in extremely shallow water (5 - 25 cm) associated with the muddy bottom in the Mad River, Ontario. Juvenile mottled sculpin were found in < 1 m of water in the littoral zone underneath cover structures such as rocks and submerged logs (Lyons 1987). Adult mottled sculpin were found at depths between 0.5 - 15 m associated with boulders in an Ontario lake (Emery 1973), and water < 1 m in Sparkling Lake, Wisconsin (Lyons 1987). At night, the mottled sculpin was recorded as being more active and present in open areas associated with sand substrate (Emery 1973).

SLIMY SCULPIN (*COTTUS CONGATUS*)

The slimy sculpin is found across northern North America from north-eastern Siberia to Virginia, Labrador and Ungava (Scott and Crossman 1973). In BC, slimy sculpin are absent from most small coastal drainages (Scott and Crossman 1973), the lower sections of the Fraser and Columbia river drainages, and coastal islands (except St. Lawrence Island, McPhail and Lindsey 1970). They are present in the Stikine, Taku, Chilkat, and Alsek rivers. The slimy sculpin is better adapted for more northern, sub-arctic conditions than other sculpin species.

Like other Cottidae, it is a benthic species, therefore inhabiting the bottom of cool streams and rivers with sandy or rocky bottoms, and lakes (McPhail and Lindsey 1970, Scott and Crossman 1973). Slimy sculpin are found at a variety of depths within lakes depending on latitude, season, time of day and food availability. In general, in higher latitude lakes, slimy sculpin inhabit shallower water (< 10 m) compared to more southern lakes where they can be found at depths of 80 m (McPhail and Lindsey 1970, McDonald et al. 1982, Brandt 1986). In Lake Superior, slimy sculpin were found at depths to 108 m (Dryer 1966).

In an Arctic lake, juvenile and adult slimy sculpin were most abundant at 3.5 m, but were present between 0.5 - 7 m (McDonald 1982). In lakes with a well developed hypolimnion, slimy sculpin occur between 0 - 10 m in spring and fall during thermal mixing, and between 4 - 10 m during the summer (Mohr 1984, 1985). In a number of lakes in Ontario, slimy sculpin changed depth on a daily basis. Emery (1973) found that during the day, slimy sculpin occupied depths of 30 - 35 m, and at night they were observed resting on sand substrate between 3 - 5 m of water. Brandt (1986) found that juvenile slimy sculpin undergo diel-feeding habitats at depths of 35 m in Lake Ontario. Juveniles move to shallower water (10 - 25 m) to feed at night. Adults that are present in 75 m of water, fed continuously and did not move to shallower water at night. Slimy sculpin have been observed to move into shallower water of lakeshores to feed on recently spawned sockeye salmon eggs (Foote and Brown 1998).

Slimy sculpin spawn starting in May, when temperatures reach between 5 - 10°C (Scott and Crossman 1973, Craig and Wells 1976, Mohr 1984). Slimy sculpin spawn mostly in rocky streams in the southern portion of its range, but will spawn over stony shores of lakes in the northern portion (McPhail and Lindsey 1970, Mohr 1984). Males select the nest, which is usually on the underside of either rocks, ledges, submerged logs, tree roots or other debris (Scott and Crossman 1973, Morrow 1980, Mohr 1984), in water < 1.5 m deep (Morrow 1980, Mohr 1984). Males may court more than one female (Scott and Crossman 1973). The females deposit the adhesive eggs on the underside of the surface (Scott and Crossman 1973) that the males then guard after spawning (McPhail and Lindsey 1970, Morrow 1980).

Mohr (1984) captured young-of-the-year slimy sculpin in a lake at 0.5 - 1.5 m depth near gravel and sand substrate with boulders and rocks. Young-of-the-year remain in shallow water where they are nocturnal feeders. As they grow, young-of-the-year move to deeper water and feed continuously (Wells 1968, Mohr 1985, Brandt 1986). When frightened, slimy sculpin bury themselves under loose substrate on the bottom (Emery 1973). Slimy sculpin mature at a size of about 7 cm (Craig and Wells 1976, Petrosky and Waters 1975, Van Vliet 1964), or two years of age (Mohr 1984). In northern lakes slimy sculpin can live up to eight years (McDonald et al. 1982).

SHORTHEAD SCULPIN (*COTTUS CONFUSUS*)

The shorthead sculpin was recognized as a distinct species in 1968 (Lee et al. 1980). It has a very small range. In Canada it is only found in southeastern BC and it is restricted to the Slocan River, the Kettle River below Cascade Falls, and some minor tributaries of the Columbia River below the Keenleyside Dam (Cannings and Ptolemy 1998). There have only been nine occurrences of this species in BC (Cannings and Ptolemy 1998), including one in the Flathead River (Peden and Hughes 1984b). Both COSEWIC and the CDC have listed the shorthead sculpin as a vulnerable species (Campbell 1998, CDC 2000). Elsewhere, the shorthead sculpin is found in Puget Sound and parts of the Columbia River drainage in Montana, Idaho, Oregon and Washington states (Page and Burr 1991). The shorthead sculpin has recently reappeared in Lake Michigan after having not been caught there for over 10 years (Potter and Fleischer 1992). This species is often found in sympatry with mottled sculpin, however it is normally found farther upstream or in smaller tributaries (Scott and Crossman 1973, Cannings and Ptolemy 1998)

This species mainly inhabits fast riffles of small cold streams (Scott and Crossman 1973, Lee et al. 1980, Peden and Hughes 1984b, Peden et al. 1989). Shorthead sculpin are also found in slow currents, over coarse substrate, such as rubble and gravel, in areas other than riffles (Peden and Hughes 1981, Cannings and Ptolemy 1998), where it will spawn underneath larger rocks and boulders (Lee et al. 1980). In Lake Michigan, shorthead sculpin were found at depths between 9 - 91 m (Potter and Fleischer 1992).

Individuals reach sexual maturity at two to three years of age depending on location, with spawning happening in early spring (Lee et al. 1980). Individuals can reach up to six years of age (Lee et al. 1980).

TORRENT SCUPLIN (*COTTUS RHOTHEUS*)

The torrent sculpin has a limited distribution in North America. In BC, it is found in the Similkameen River drainage, the Kettle River, the Columbia River between Kinbasket Lake and the United States border, in Kootenay Lake and upper system, and in a few locations in the North Thompson drainage (Carl et al. 1967, Scott and Crossman 1973). Elsewhere, they are distributed in the Puget Sound drainage (Scott and Crossman 1973), and the Columbia River drainage in Montana, Idaho, Oregon and Washington states (Page and Burr 1991).

Sexual maturity probably occurs by age two, with spawning taking place in late June to August (Northcote 1954). This species is most often found in association with rubble and gravel substrates in riffles (Page and Burr 1991). In lakes, torrent sculpin have been found in the upper littoral zone (Northcote 1954) over rocky substrate (Page and Burr 1991, Taylor 2001).

SPOONHEAD SCULPIN (*COTTUS RICEI*)

Spoonhead sculpin are found across North America, from the St. Lawrence River and Great Lakes to the BC-Alberta border and north to Great Slave Lake, NWT, and the lower Mackenzie River drainage (McAllister 1962, Scott and Crossman 1973). Spoonhead sculpin are limited to the north-eastern corner of BC in the Peace and Mackenzie river drainages (Scott and Crossman 1973).

In the western part of its range, spoonhead sculpin are more common in running water, than lakes (McPhail and Lindsey 1970, Dadswell 1972). In lakes they are found at depths between 15 - 100 m and greater (Deason 1939, Dryer 1966, Delisle and van Vliet 1968, Scott and Crossman 1973), and in shallow areas (Deason 1939, McPhail and Lindsey 1970, Dadswell 1972). Optimum depth is thought to be around 70 m (Scott and Crossman 1973). In shallow, turbid lakes in Ontario, spoonhead sculpin were found between 5 - 10 m depths at 18°C (Dadswell 1972). Spoonhead sculpin also occur in rocky, small, fast streams (Page and Burr 1991) and muddy, turbid rivers (Scott and Crossman 1973). Their abundance within any one location is often low, despite their large range and variable habitat use (McPhail and Lindsey 1970). The distribution of spoonhead sculpin is thought to be related to the location of glacial lakes formed after the Wisconsin glaciation period (Houston 1990).

The life history of the spoonhead sculpin is largely unknown. It is relatively small compared to other sculpins, although individuals as large as 110 mm have been taken from Pemichangan Lake, Quebec (Delisle and Van Vliet 1968). Spawning is thought to take place during late summer or early fall (Delisle and van Vliet 1968), however no direct observations of spawning have been recorded.

SUNFISHES (*CENTRARCHIDAE*)

PUMPKINSEED (*LEPOMIS GIBBOSUS*)

Pumpkinseeds have been introduced across the western United States (Scott and Crossman 1973), and into BC as they are present in lakes and streams on Vancouver Island, and the Columbia, Okanagan, and lower Fraser river drainages (BC Fisheries 2000a). Their native range extends from New Brunswick, through the Great Lakes to eastern Manitoba, south to Ohio, Missouri, South Dakota and north-western Georgia (Scott and Crossman 1973).

The typical habitat of pumpkinseeds is in shallow, vegetated areas of ponds, small lakes, bays of large lakes, and slow areas of large rivers over a range of substrates (Emery 1973, Scott and Crossman 1973, Brown et al. 2000).

Spawning typically takes place during late spring and early summer (Scott and Crossman 1973). Although in the southern portion of the range, spawning lasts until the end of August. Water temperatures during spawning are around 20°C. Males build nests in water < 1 m deep by clearing away the substrate (rock to clay) until a clean, hard surface is exposed. Nests are built near vegetation, and exposed roots of plants. Males may build more than one nest or reuse the same nest during a single spawning season, and females will lay eggs in more than one nest. The adhesive eggs adhere to the substrate, debris and roots within the nest. Males defend the nest and larvae once they hatch (three days at 28°C) for up to 11 days. The young-of-the-year grow fairly fast within their first summer (Reid 1930, Smith 1952, MacKay 1963), but this largely depends on population size (Scott and Crossman 1973).

Juvenile pumpkinseed school in shallow water often 0.1 - 0.5 m in depth associated with emergent plants (Emery 1973). Adult pumpkinseeds are found in slightly deeper water than juveniles (1 - 5 m), and are more associated with rocky or plant covered substrate. Resting areas for pumpkinseeds are in the interstices of rocks or submerged logs. Brown et al. (2000) found pumpkinseeds associated with submerged wood and cobble substrate at 2 m depth in the littoral zone.

Sexual maturity is at two years of age, and maximum age is around nine years (Scott and Crossman 1973). Upper lethal temperature limit is 28 - 30°C (Black 1953).

SMALLMOUTH BASS (*MICROPTERUS DOLOMIEU*)

In BC, smallmouth bass have been introduced onto Vancouver Island, and into the Okanagan and Columbia river drainages (BC Fisheries 2000a). Their native range is within eastern central North America from the Great Lakes and the St. Lawrence River south to the Ohio, Tennessee and upper Mississippi river drainages (Scott and Crossman 1973). Smallmouth bass are typically found in small, shallow lakes (Emery 1973, Scott and Crossman 1973, Hubert and Lackey 1980, Johnson et al. 1977, Brown et al. 2000). Their preferred temperature level is between 20.3 - 21.4°C, with a lethal upper limit of 35°C (Scott and Crossman 1973). Scott and Crossman (1973) remark that movements made by smallmouth bass are to remain within the preferred temperature range.

Timing of spawning in Lake Opeongo, Ontario is between mid-May and mid-June (Ridgway and Friesen 1992). In general, spawning takes place when water temperatures reach 12.8 - 20°C (Scott and Crossman 1973). Males build a nest in sand, gravel and rock substrates in water 0.6 - 6 m deep in lakes and rivers. Females will deposit eggs in more than one nest over the spawning period. Males tend the nest once the female has deposited her eggs (Ridgway and Friesen 1992). Eggs are adhesive and attach to coarse substrate within the nest (Scott and Crossman 1973). Males will stay with the nest until the eggs have hatched and the larvae metamorphose into young-of-the-year (Scott and Crossman 1973, Ridgway and Friesen 1992). The process of spawning to the dispersal of young-of-the-year can take between 19 - 45 days (Ridgway and Friesen 1992). Males may abandon the nest at any point during this period. Ridgway and Friesen (1992) found that offspring from larger males that spawned early in the breeding season take longer to develop than offspring from males that spawned late in the season. Growth of smallmouth bass within the first year is usually very rapid (Smith 1942, White 1970, Scott and Crossman 1973). Higher growth rate is associated with warmer water for individuals three to five years of age in Lake Huron, Ontario (Coble 1967).

Young-of-the-year smallmouth bass are found over sand, or silted rocks (Brown et al. 2000). Usually, young-of-the-year smallmouth bass are segregated from larger smallmouth bass (Webster 1954, Walters and Wilson 1996, Brown et al. 2000). In rivers, young-of-the-year are thought to be habitat generalists and are found over boulder to silt substrates, associated with submerged vegetation in pool and run habitats (Walters and Wilson 1996). Juvenile smallmouth bass from lakes can be found near clean cobble substrates and submerged woody debris (Brown et al. 2000).

Smallmouth bass frequent shallow waters during the day (Emery 1973, Tabor et al. 1993). During the day, adult smallmouth bass are associated with boulders, clean cobble, submerged woody debris and emergent vegetation in water < 5 m deep (Emery 1973, Hubert and Lackey 1980, Brown et al. 2000). At night, smallmouth bass move into water between 3 - 10 m deep to rest on the bottom underneath woody debris and rocks (Emery 1973). Night-time collections in the John Day Reservoir were successful in capturing smallmouth bass in the nearshore area within the top 7 m of water (Beamesderfer and Rieman 1991).

Sexual maturity is between ages three to five for males and ages four to six for females (Scott and Crossman 1973). Smallmouth bass spawn each year between the ages of four and 12 years (Scott and Crossman 1973, Ridgway and Friesen 1992). The oldest specimen recorded from Canada was 15 years of age (Scott and Crossman 1973). Smallmouth bass are a known predator of juvenile salmonids (Tabor et al. 1993).

LARGEMOUTH BASS (*MICROPTERUS SALMOIDES*)

In BC, largemouth bass are present in the south-western corner of the province, including the lower Fraser River drainage, and in the interior in the Okanagan and Columbia river drainages (Scott and Crossman 1973, BC Fisheries 2000a). The native range of largemouth bass is in the lower Great Lakes and central Mississippi River drainage, south to the Gulf coast and Florida up the coast to Virginia (Scott and Crossman 1973). Largemouth bass have been introduced across the United States.

Largemouth bass are found in deep water (> 6 m) in the littoral zone of small, warm lakes, bays of large lakes and rarely large, slow rivers (Jeppson and Platts 1959, Scott and Crossman 1973, Beauchamp et al. 1995). Upper lethal temperature limit is 29°C (Black 1953).

Spawning takes place during late spring to early summer or August, with peak spawning during mid-June (Scott and Crossman 1973). Nest building commences when water temperatures reach at least 15.6°C and spawning begins at 16.7 - 18.3°C. Males build nests over gravel, sand to soft mud substrates near reeds, bullrushes and water lilies, in water < 2 m deep. Males clear the area for the nests, which often consist of exposed roots of emergent plants. Females will lay the demersal, adhesive eggs in more than one nest within the breeding season. Eggs hatch within three to five days and remain in the nest for up to a month. The male guards the nest and the young-of-the-year for all or part of this time. Growth is rapid for young-of-the-year during the first summer (Trautman 1957). Predation and nest deterioration are two major causes for the poor survival rate of eggs and young-of-the-year (Scott and Crossman 1973). Largemouth bass reach sexual maturity by ages three to four for males, and ages four to five for females. Maximum age is around 15 years.

BLACK CRAPPIE (*POMOXIS NIGROMACULATUS*)

On the west coast, black crappies have been introduced to coastal waters in Oregon and Washington states and south-western BC including the lower Fraser River (Scott and Crossman 1973, BC Fisheries 2000a). Recently, black crappies have also been introduced, or have spread into the Okanagan River drainage (BC Fisheries 2000a). The native range of black crappies is within fresh and sometimes brackish water of central and eastern North America from the St. Lawrence River and Quebec, south to Florida, west to Texas, and north again to North Dakota and Ontario (Scott and Crossman 1973). Black crappies usually inhabit vegetated areas in clear, calm and warm ponds, small lakes or shallow bays of large lakes, and slow large rivers. Black crappies are found over sand, mud substrates.

Very little is known about the biology of black crappies, especially in Canadian waters. Spawning takes place during late spring and early summer when water temperatures reach 19 - 20°C (Scott and Crossman

1973). Males build a nest in very shallow water (< 1 m deep), by clearing away mud, sand and gravel. Nests are often built near vegetation or undercut banks. Females deposit eggs in more than one nest within a spawning season. Eggs are demersal and adhesive. Males fan the eggs until they hatch (three to five days), at which time the males will defend the young-of-the-year until they leave the nest. Growth of larvae and young-of-the-year is rapid within the first summer (Beckman 1949, Trautman 1957), but this depends largely on the productivity of the habitat and the population abundance (Scott and Crossman 1973). Sexual maturity occurs by ages two to four, and maximum age is between eight to ten years (Beckman 1949, Scott and Crossman 1973).

PERCHES (*PERCIDAE*)

YELLOW PERCH (*PERCA FLAVESCENS*)

Yellow perch exist in BC due to their expansion from both introduced and native populations outside the province. In southern BC in the Pend Oreille, Okanagan and Columbia river watersheds, yellow perch have moved north from introduced populations in Washington State (Scott and Crossman 1973). In the Peace River, yellow perch have expanded from native populations in Alberta (BC Fisheries 2000a). The yellow perch is native to Alberta, across North America to Nova Scotia and South Carolina (Scott and Crossman 1973). Yellow perch have been introduced into Washington, Oregon, California, Utah, New Mexico and Texas, and have moved into Florida and Alabama, possibly because they are a highly adaptable species that can utilize a wide range of habitat types.

Yellow perch inhabit warm and cool lakes, ponds, and slow-flowing rivers, and in some areas brackish and saline water (McKenzie 1959, Scott and Crossman 1973). They are known to occur in open, shallow water and on the bottom, often in schools (Hergenrader and Hasler 1968, Reckahn 1970, Emery 1973, Scott and Crossman 1973, Lyons 1987, Beauchamp et al. 1995). During the summer schools are dense and small, compared to schools in the winter which are more loosely aggregated (Hergenrader and Hasler 1968). The difference in school size between the seasons is attributed to temperature. They inhabit water 19 - 21°C in temperature (Ferguson 1958). The upper lethal temperature limit is 26.5° in BC (Scott and Crossman 1973) and 26 - 29°C and 33°C in other locations (Black 1953). Yellow perch feed in open water and off the bottom during the morning and evening (Scott and Crossman 1973).

Spawning takes place during the spring between mid-April and May or July when water temperatures reach 6.7 - 12.2°C (Scott and Crossman 1973). Yellow perch move to shallow areas of lakes and into tributary streams to spawn. Spawning takes place in areas with rooted vegetation, submerged brush and sunken logs over sand and gravel substrates. A female may mate with more than one male during spawning. The eggs are deposited within a semi-buoyant, gelatinous string or tube that can reach up to 2.1 m in length. The tube of eggs adheres to the vegetation or the bottom, and moves within the water column to increase aeration. Eggs hatch within eight to ten days, or up to 27 days at 8.3°C. After the yolk is absorbed (five days) the young-of-the-year grow rapidly (Trautman 1957). Juvenile yellow perch often form schools with minnows (if present) such as spottail shiner, in shallow nearshore habitats (Scott and Crossman 1973). Juveniles were collected in the nearshore area in water < 2 m deep in Wilson Lake, Minnesota (Johnson 1977), and to 18 m in Lake Huron (Berst and McCombie 1963).

During the spring, adult yellow perch move in and out of deeper water, and up and down in the water column, possibly in response to temperature and food availability (Scott and Crossman 1973). They are inactive at night and rest on the bottom. Yellow perch are usually not found in water > 30 m deep (Emery 1973, Scott and Crossman 1973, Lyons 1987, Beauchamp et al. 1995). They have been found in water 1.5 - 3 m (Emery 1973), 2 - 4 m deep (Lyons 1987) and ≤ 15 m (Beauchamp et al. 1995) in the nearshore littoral zone of lakes. Yellow perch use vegetation, sunken woody debris and rocks as cover (Emery 1973). Yellow perch can be found in water > 15 m deep and over 30 m deep (Ferguson 1958, Hergenrader and Hasler 1968, Reckahn 1970, Emery 1973, Beauchamp et al. 1995), usually associated with the bottom (Emery 1973), or the 20°C isotherm (Ferguson 1958).

Growth rate is faster in warmer water of the southern portion of the range (Smith 1939, Lawler 1953, Sheri and Power 1969, Scott and Crossman 1973), however individuals live longer in the north (Scott and Crossman 1973). Maximum age on average is between nine to ten years, but older individuals (11+ years) have been caught thoughout their range. Females attain a larger size overall. Sexual maturity is at three years of age for males and four years of age for females.

WALLEYE (*STIZOSTEDION VITREUM VITREUM*)

Walleye are both introduced and native to BC. Walleye are native to the Liard and Peace river drainages in north-eastern BC (Scott and Crossman 1973). Walleye have been introduced to many western states in the Unites States, and as a result have moved into southern BC through the Columbia River drainage (BC Fisheries 2000a). The natural distribution of walleye is from the mouth of the Mackenzie River south to north-eastern BC, and southern Alberta, across and south to Alabama, and north again to New Hampshire and Quebec (Scott and Crossman 1973).

Walleye are sensitive to bright light, so are common in fairly turbid small and large lakes and reservoirs (Dymond and Scott 1941, Rawson 1951, Scott and Crossman 1973, Johnson et al. 1977, Beamesderfer and Rieman 1991, Jones et al. 1994). They can also be found in rivers, as long as the water is deep and turbid (Scott and Crossman 1973). They avoid strong currents. In clear lakes, walleye will either associate with cover structures such as sunken logs, vegetation, boulders and even ice or snow, or settle in deep water to avoid direct sunlight (Scott and Crossman 1973, Johnson et al. 1977). In Ontario, walleye were most common in shallow lakes that have a large percentage of the lake area within the littoral zone (Johnson et al. 1977). In larger lakes, walleye avoid deep water areas, and remain along the shallow shoreline (Ryder 1968). In turbid lakes, walleye are active in summer and winter, slowly swimming in shallow water searching for food (Rawson 1951, Scott and Crossman 1973). In the large Great Slave Lake, NWT, walleye were restricted to river mouths in water < 5 m deep (Rawson 1951).

Timing of spawning varies with latitude. Walleye spawn in early-April in southeastern Ontario, and in late-June or later, after ice break-up, in the northern portion of its range (Ryder 1968, Scott and Crossman 1973). Prespawning behaviour will commence at a water temperature of 1.1°C, but temperatures must reach at least 5.6 - 11.1°C before spawning will occur (Scott and Crossman 1973). Spawning takes place either in rocky areas in rivers below dams and falls, or on lake shores over coarse gravel to boulder substrates (Martin 1956, Scott and Crossman 1973, Ford et al. 1995). In rivers, preferred water velocity for spawning has been estimated to be between 0.15 - 0.25 m/s (Stevens 1990, DiStefano and Hiebert 1999), and up to 0.6 - 1.5 m/s (Paragamian 1989, Pitlo 1989, Siegwarth 1993). Walleye avoid sand, muck and mud substrates during spawning (Martin 1956). Walleye return to the same river to spawn in successive years (Eschmeyer and Crowe 1955, Rawson 1957, Crowe 1962, Olson and Scidmore 1962, Forney 1963, Ryder 1968). Spawning groups can consist of two to eight individuals, with up to two females within the group (Scott and Crossman 1973). At night, the spawning group will rush into shallow areas and emit eggs and sperm into the water. The fertilized eggs fall into the cervices between the substrate. Hatching time of eggs varies. Campbell and Rowes (1980) reported 60 days for eggs to hatch. In general, eggs hatch within 12 - 18 days, and are free swimming 10 - 15 days after hatching (Scott and Crossman 1973). Young-of-the-year walleye are thought to move offshore, into surface water after hatching (Martin 1956, Houde 1969, Houde and Forney 1970, Scott and Crossman 1973), and return to the littoral zone only after they attain a size of 30 - 40 mm in length (House and Forney 1970). By the end of the summer, young-of-the-year walleye move into deeper water and associate with the bottom (Scott and Crossman 1973).

Juvenile walleye are common in nearshore areas in water < 2 m deep (Johnson 1977, Jones et al. 1994), although they can be found to much deeper depths (Ryder 1977). Movement of walleye within a lake outside the spawning season, is thought to be minimal (Forney 1963), and can range from 0 - 0.18 miles/day (Ryder 1968). Juvenile and adult walleye make daily movements along the shoreline in search of food, and also in response to light and temperature levels (Scott and Crossman 1973). Walleye in Lac La Rouge, Saskatchewan, remained at depths where water temperatures ranged from 13 - 18°C. In the John Day Reservoir on the Columbia River, walleye were most abundant in the area below the McNary Dam (Beamesderfer and Rieman 1991).

Sexual maturity of male walleye is between two to four years of age, and females between three to six years of age (Scott and Crossman 1973). Walleye from northern populations will reach 20 years of age, while southern populations die after 10 - 12 years (Scott and Crossman 1973).

SUMMARY AND RECOMMENDATIONS

There are obvious gaps in information pertaining to all species, but in particular to non-sport species such as the minnows, suckers, smelts, ciscos, some sculpin and lamprey species, sturgeons and goldeye. In some cases, for example the white sturgeon, there is a growing body of research regarding spawning and riverine requirements, but there is very little information on lake habitat associations. For many species (e.g. slimy sculpin, cisco), most of the information presented here comes from populations from eastern Canada or the United States. Basic research on general riverine and lacustrine habitat requirements in BC is greatly needed for these species. The information presented in this report is a useful reference for lake habitat requirements of British Columbian freshwater fish species, however more research is needed to fill in gaps that exist. Determining basic distribution within watersheds, or more generally within the province, would be a useful start for some species where there is virtually no information available.

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Table 1: List of freshwater fish species occurring in British Columbia. Data taken from McPhail

Common Name	Scientific Name	Fra	Col	Mac	Yuk	NC	CC	QCI	VI
Lampreys	Petromyzontidae								
River lamprey	*Lampetra ayresi*	X				X	X		X
Lake lamprey	*Lampetra macrostoma*								X
Western brook lamprey	*Lampetra richardsoni*	X				X	X	X	X
Pacific lamprey	*lampetra tridentata*	X				X	X	X	X
Sturgeons	Acipenseridae								
Green sturgeon	*Acipenser medirostris*	X				X	X		X
White sturgeon	*Acipenser transmontanus*	X	X			X	X		
Mooneyes	Hiodontidae								
Goldeye	*Hiodon alosoides*			X					
Herrings	Clupeidae								
American shad	*Alosa sapidissima*	I				I	I		
Carps and Minnows	Cyprinidae								
Chiselmouth	*Acrocheilus alutaceus*	X	X						
Goldfish	*Carassius auratus*	X	I						I
Lake chub	*Couesius plumbeus*	X	X	X	X	X	X		
Common carp	*Cyprinus carpio*	X	I/X						I
Brassy minnow	*Hybognathus hankinsoni*	X		X					
Pearl dace	*Margariscus margarita*			X					
Peamouth chub	*Mylocheilus caurinus*	X	X	X			X		X
Emerald shiner	*Notropis atherinoides*			X					
Spottail shiner	*Notropis hudsonius*			X					
Northern redbelly dace	*Phoxinus eos*			X					
Finescale dace	*Phoxinus neogaeus*			X					
Fathead minnow	*Pimephales promelas*	I		I					I
Flathead chub	*Platygobio gracilis*			X					
Northern pikeminnow	*Ptychocheilus oregonensis*	X	X	X			X		
Longnose dace	*Rhinichthys cataractae*	X	X	X			X		
Leopard dace	*Rhinichthys falcatus*	X	X						
Speckled dace	*Rhinichthys osculus*		X						
Umatilla dace	*Rhinichthys umatilla*		X						
Redside shiner	*Richardsonius balteatus*	X	X	X			X		
Tench	*Tinca tinca*		I						
Suckers	Catostomidae								
Longnose sucker	*Catostomus catostomus*	X	X	X	X	X	X		
Bridgelip sucker	*Catostomus columbianus*	X	X						
White sucker	*Catostomus commersoni*	X		X					
Largescale sucker	*Catostomus macrocheilus*	X	X	X			X		
Mountain sucker	*Catostomus platyrhynchus*	X	X						

X=species present in watershed, I=species introduced to watershed, Fra=Fraser River watershed, Col=Columbia River watershed, Mac=Mackenzie River watershed, Yuk=Yukon River watershed, NC=North Coast watersheds, CC=Central Coast watersheds, QCI=Queen Charlotte Islands, VI=Vancouver Island.

Table 1. Continued.

Common Name	Scientific Name	Fra	Col	Mac	Yuk	NC	CC	QCI	VI
Bullhead Catfishes	Ictaluridae								
Black bullhead	*Ameiurus melas*		I						
Brown bullhead	*Ameiurus nebulosus*	I	I						I
Pikes	Esocidae								
Northern pike	*Esox lucius*			X	X	X			
Smelts	Osmeridae								
Surf smelt	*Hypomesus pretiosus*								
Rainbow smelt	*Osmerus mordax*								
Longfin smelt	*Spirinchus thaleichthys*	X				X	X		X
Eulachon	*Thaleichthys pacificus*	X				X	X	X	X
Trouts and Salmons	Salmonidae								
Cisco	*Coregonus artedi*			X					
Arctic cisco	*Coregonus autumnalis*			X					
Lake whitefish	*Coregonus clueaformis*	I/X	I	X	X	X	X		
Broad whitefish	*Coregonus nasus*				X				
Least cisco	*Coregonus sardinella*				X				
Cutthroat trout	*Oncorhynchus clarki*	X	X			X	X	X	X
Pink salmon	*Oncorhynchus gorbuscha*	X				X	X	X	X
Chum salmon	*Oncorhynchus keta*	X			X	X	X	X	X
Coho salmon	*Oncorhynchus kisutch*	X				X	X	X	X
Rainbow trout	*Oncorhynchus mykiss*	X	X	X		X	X	X	X
Sockeye salmon	*Oncorhynchus nerka*	X	I/X			X	X	X	X
Chinook salmon	*Oncorhynchus tshawytscha*	X			X	X	X	X	X
Pygmy whitefish	*Prosopium coulteri*	X	X	X	X	X	X		
Round whitefish	*Prosopium cylindraceum*			X	X	X			
Mountain whitefish	*Prosopium williamsoni*	X	X	X		X	X		
Atlantic salmon	*Salmo salar*								I
Brown trout	*Salmo trutta*		I						I
Bull trout	*Salvelinus confluentus*	X	X	X	X	X	X		
Brook trout	*Salvelinus fontinalis*	I	I	I					I
Dolly Varden trout	*Salvelinus malma*	X		X		X	X	X	X
Lake trout	*Salvelinus namaycush*	X	I	X	X	X	X		
Inconnu	*Stenodus leucichthys*			X	X				
Arctic grayling	*Thymallus arcticus*		I	X	X	X			
Trout-Perches	Percopsidae								
Trout-perch	*Percopsis omiscomaycus*			X					
Cods	Gadidae								
Burbot	*Lota lota*	X	X	X	X	X	X		
Sticklebacks	Gasterosteidae								
Brook stickleback	*Culaea inconstans*			X					
Threespine stickleback	*Gasterosteus aculeatus*	X				X	X	X	X
Ninespine stickleback	*Pungitius pungitius*			X					

Table 1. Continued.

Common Name	Scientific Name	Fra	Col	Mac	Yuk	NC	CC	QCI	VI
Sculpins	Cottidae								
Coastrange sculpin	*Cottus aleuticus*	X				X	X	X	X
Prickly sculpin	*Cottus asper*	X	X	X		X	X	X	X
Mottled sculpin	*Cottus bairdi*		X						
Slimy sculpin	*Cottus cognatus*	X	X	X	X	X			
Shorthead sculpin	*Cottus confusus*		X						
Torrent sculpin	*Cottus rhotheus*	X	X						
Spoonhead sculpin	*Cottus ricei*			X					
Sunfishs	Centrarchidae								
Pumpkinseed	*Lepomis gibbosus*	I	I						I
Smallmouth bass	*Micropterus dolomieu*		I						I
Largemouth bass	*Micropterus salmoides*	I	I						
Black crappie	*Pomoxis nigromaculatus*	I	I						
Perches	Percidae								
Yellow perch	*Perca flavescens*		I/X	X					
Walleye	*Stizostedion vitreum*		I	X					

Figure 1. Map of British Columbia.

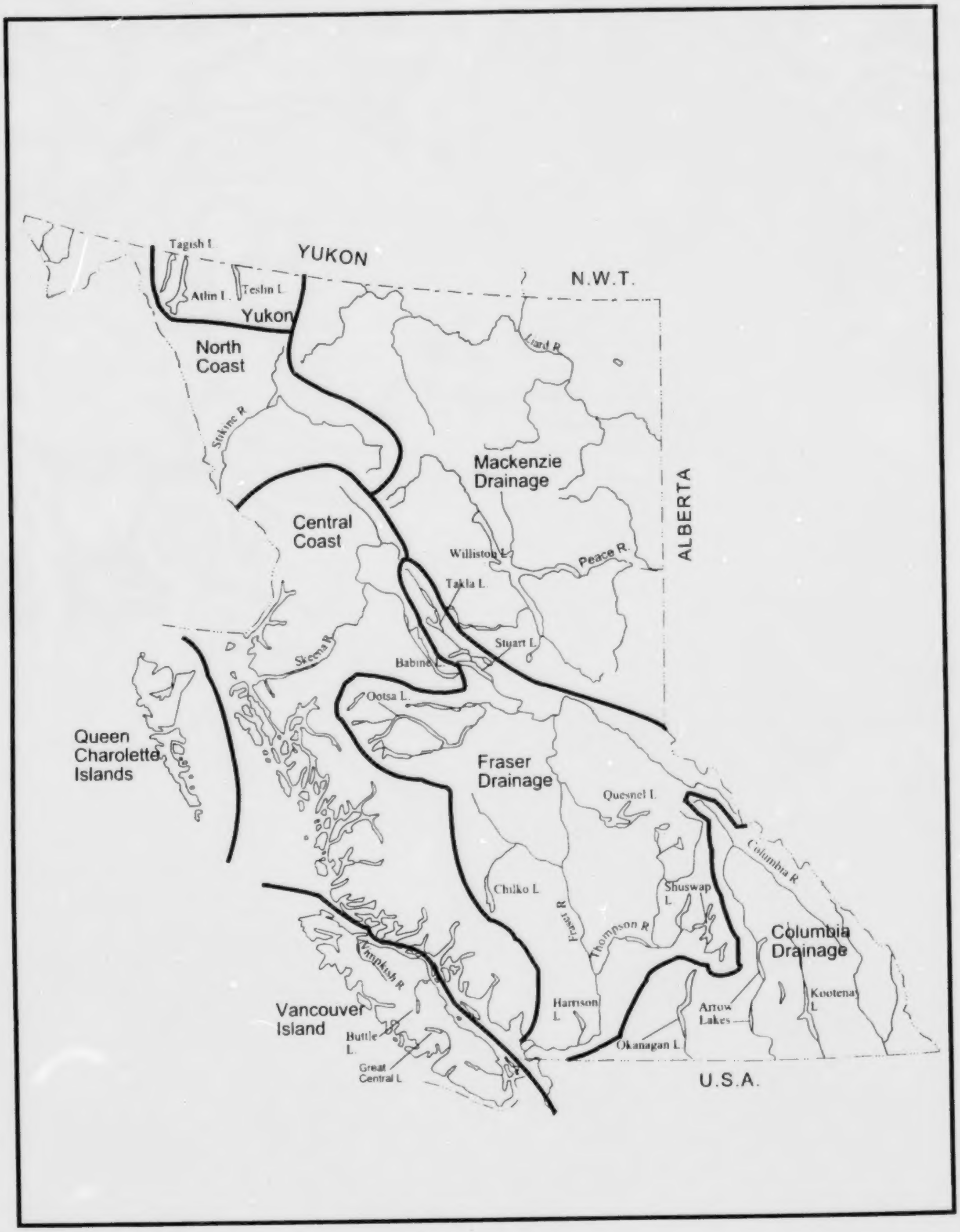
Tagish L.
YUKON
Atlin L.
Teslin L.
Yukon
N.W.T.
North Coast
Liard R.
Stikine R.
Mackenzie Drainage
ALBERTA
Central Coast
Williston L.
Peace R.
Takla L.
Skeena R.
Stuart L.
Babine L.
Ootsa L.
Queen Charolette Islands
Fraser Drainage
Quesnel L.
Columbia R.
Chilko L.
Shuswap L.
Fraser R.
Thompson R.
Columbia Drainage
Nimpkish R.
Kootenay L.
Vancouver Island
Harrison L.
Arrow Lakes
Buttle L.
Okanagan L.
Great Central L.
U.S.A.

Table 2. Lacustrine habitat requirements for river lamprey.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres								
1-2 metres								
2-5 metres								
5-10 metres								
10+ metres			L	L			1	1,2
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Limnetic			L				1	
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Caught in Cultus, Harrison, Lakelse, and Kitsumkalum lakes along the coast (1), and Nimpkish Lake on Vancouver Island (2).

Sources for Table:

1. Hume, J., Fisheries and Oceans Canada, personal communication.
2. Simpson et al. 1981.

Table 3. Lacustrine habitat requirements for Vancouver Island lamprey.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H				1,2			
1-2 metres	H							
2-5 metres								
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel	H				1,2			
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Non-anadromous (Cannings and Ptolemy 1998).
Found only in two lakes on Vancouver Island, Cowichan Lake and Mesachie Lake (Cannings and Ptolemy 1998, Docker et al. 1999.).

Sources for Table:

1. Beamish 1984.
2. Beamish 1987.

Table 4. Lacustrine habitat requirements of white sturgeon.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres				*H*				1
1-2 metres				*H*				1
2-5 metres				H				1,2
5-10 metres				H				2
10+ metres				H				1,2
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
During the spring, white sturgeon have been reported basking near the surface in Williams, Trembleur, and Harrison lakes (1).
During the fall, white sturgeon inhabit depths between 3-40 m in Kootenay Lake (2).
During the later fall, white sturgeon may move into deep water (10-100 m deep) of Kootenay Lake to overwinter (1).
They are predominantly found in deep, slow water of large rivers (Ford et al. 1995, Perrin et al. 1999).

Sources for Table:

1. Cannings and Ptolemy 1998.
2. R.L. & L. Environmental Services Ltd. 1998.

Table 5. Lacustrine habitat requirements for goldeye.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*H*	*H*	H	H	1	1,2	2	2
1-2 metres	*H*	*H*	H	H	1	1,2	2	2
2-5 metres	*H*	*H*	H	H	1	1,2	2	2
5-10 metres				*M*				3
10+ metres				*M*				3
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Juveniles and adults found in water < 5 m deep in Great Slave Lake (2).
Goldeyes may overwinter in deep areas of lakes (3).
Spawning takes place on shallow nearshore areas (1).

Sources for Table:

1. Battle and Sprules 1960.
2. Rawson 1951.
3. Scott and Crossman 1973.

Table 6. Lacustrine habitat requirements for chiselmouth.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres			*H*	*H*			1	1
1-2 metres			*H*	*H*			1	1
2-5 metres			*H*	*H*			1	1
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder			*H*	*H*			1	1
Rubble			*H*	*H*			1	1
Cobble			*M*	*M*			1	1
Gravel			*M*	*M*			1	1
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Chiselmouth are thought to move into lakes to overwinter (Rosenfeld et al. 2000b).
Presumably, chiselmouth are found in the shallow littoral zone of lakes, associated with coarse substrate, since they feed on algae that grows on these rocks (1).

Sources for Table:

1. G. Haas personal communication.

Table 7. Lacutsrine habitat requirements for goldfish.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	*H*	*H*	2	2	2	2
1-2 metres	H	*H*	*H*	*H*	2	2	2	2
2-5 metres		*H*	*H*	*H*		2	2	2
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)		*H*	*H*	H		1,2	1,2	1,2
Limnetic								
Cover:								
None								
Submergents	H	*H*			2	2		
Emergents	H	*H*	*H*	H	2	2	1,2	1,2
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Goldfish are presumably found in shallow, vegetated areas of muddy, turbid lakes (1,2).

Sources for Table:

1. Page and June 1991.
2. Scott and Crossman 1973.

Table 8. Lacustrine habitat requirements for lake chub.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	*H*	H	2,5,6	2,5,6	1,4,5	1,4,5
1-2 metres	H	*H*	*H*	H	2,5,6	2,5,6	1,4,5	1,4,5
2-6 metres	H	*H*	*H*	H	2,5,6	2,5,6	1,4,5	1,4,5
6-10 metres			*M*	M			4,6	3,4,6,7
10+ metres			*M*	M			4,6	3,4,6,7
Substrate:								
Bedrock								
Boulder				H				1
Rubble	H	*H*			2,5	2,5		
Cobble	H	*H*			2,5	2,5		
Gravel	H	*H*			2,5	2,5		
Sand				M				1
Silt	M	*M*			2	2		
Muck (detritus)	M	*M*			2	2		
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Typically, lake chub are found in shallow areas near the bottom in lakes and sometimes streams and rivers (1, 4, 5, McAllister 1961).
Often found over sand substrate with boulders intermixed (1).
Lake chub have been found in deep water, associated near the bottom (3, 4, 6, 7).
Lake chub spawn over a variety of substrates and detritus (2).

Sources for Table:

1. Becker 1980.
2. Brown et al. 1970.
3. Burgess 1978.
4. Emery 1973.
5. McPhail and Lindsey 1970.
6. Morrow 1980.
7. Scott and Crossman 1973.

Table 9. Lacustrine habitat requirements for common carp.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	*H*	H	3,4	4	4	4
1-2 metres	H	H	H	H	3,4	4	4	4
2-5 metres			H	H			4	4
5-10 metres			*M*	M			4	4
10+ metres			*M*	*M*			4	4
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)	H				4			
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents	H	*H*	*H*	*H*	4	4	1	1,4
Emergents	H	*H*	*H*	*H*	2,3,4	4	1	1,4
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Common carp spawn in shallow, mucky areas of lakes near vegetation (2, 3, 4).
Found in lakes and rivers, associated with the bottom (Clemens et al. 1939, Brown and Coon 1994).
Adults stay in shallow water suring the summer (2, 5), and move into deeper water during the winter (5).
Presumably juvenile common carp utilize the same habitat as the adults.

Sources for Table:

1. G. Haas personal communication.
2. McCrimmon 1968.
3. Scott and Crossman 1973.
4. Swee and McCrimmon 1966.

Table 10. Lacustrine habitat requirements for brassy minnow.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	*H*	*H*	1,2,3	1,2,3	4	4
1-2 metres	H	*H*	*H*	*H*	1,2,3	1,2,3	4	4
2-5 metres			*H*	*H*			4	4
5-10 metres			*L*	*L*			4	4
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel		*H*	*H*	H		3	3	3
Sand	M	*H*	*H*	H	2	3	3	3
Silt	M				2			
Muck (detritus)	M	*H*	*H*	H	2	3	3	3
Clay (mud)		*H*	*H*	H		3	3	3
Limnetic		*H*	*H*	*H*		4	4	4
Cover:								
None	M				1,2,3			
Submergents	H				1,2,3			
Emergents	H				1,2,3			
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Brassy minnows spawn in shallow areas in lakes over sand, silt and detritus (1, 2, 3).
Brassy minnows overwinter near cover and burrow in debris (2).
This species forms schools that presumably inhabit the shallow limnetic zone of small interior BC lakes (4).

Sources for Table:

1. Becker 1983.
2. Dobie et al. 1956.
3. Cannings and Ptolemy 1998.
4. G. Haas personal communication.

Table 11. Lacustrine habitat requirements for pearl dace.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	*H*	*H*	3	3	2	2
1-2 metres	H	*H*	*H*	*H*	3	3	2	2
2-5 metres	H	*H*	*H*	*H*	3	3	2,3	2,3
5-10 metres			*H*	*H*			3	3
10+ metres			*H*	*H*			3	3
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)	H				1			
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents	H				3			
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
In BC, there may be no "pure" populations of pearl dace (McPhail and Carveth 1993b).
They inhabit a variety of habitats depending on the location within the range. In BC, pearl dace typically inhabit slow flowing, tea coloured creeks (Cannings and Ptolemy 1998).
In lakes, pearl dace inhabit a range of depths (2, 3) possibly because of temperature (3).
Presumably, juveniles inhabit similar habitat as the adults.

Sources for Table:

1. Bendell and McNicol 1987.
2. G. Haas personal communication.
3. Tallman et al. 1984.

Table 12. Lacustrine habitat requirements for peamouth chub.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	*H*	H	8	2,8	1,3,4,5	1,3,4,5
1-2 metres		*H*	*H*	H		2,8	1,3,4,5	1,3,4,5
2-5 metres		*H*	*H*	H		2	1,3,4,5	1,3,4,5
5-10 metres		*M*	*M*	M		2	1,3,4	1,3,4
10+ metres		*L*	*L*	L		2	1,3	1,3
Substrate:								
Bedrock								
Boulder								
Rubble	H	*H*			8	8		
Cobble	H	*H*			8	8		
Gravel	H	*H*			8	8		
Sand	Nil				8			
Silt	Nil				8			
Muck (detritus)								
Clay (mud)								
Limnetic				L				6,7
Cover:								
None								
Submergents								
Emergents				H				9
Overhead	L				8			
In situ								
Other								

[1]Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2]Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Primarily profundal-littoral species (1), but some have been found caught in limnetic zone (6, 7).
In Lakelse Lake, BC, peamouth chub form small schools and inhabit shallow, vegetated water of lakes and rivers (1, 3, 4, 5, 9, Clemens et al. 1939, Porter and Rosenfeld 1999).
Peamouth chub spawn over stony, rubble substrate in shallow nearshore areas (8).
Young-of-the-year remain in shallow nearshore areas until the end of their first summer, after which they move into deeper water (2).

Sources for Table:

1. Beauchamp et al. 1995.
2. Carl et al. 1967.
3. Godfrey 1955.
4. Narver 1967.
5. Ricker 1952.
6. Scarsbrook and McDonald 1973.
7. Scarsbrook and McDonald 1975.
8. Schultz 1935.
9. Scott and Crossman 1973.

Table 13. Lacustrine habitat requirements for emerald shiner.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres		H	H	M		2,3	2,3	2,3
1-2 metres	H	H	H	H	1	2,3	2,3	2,3
2-5 metres	H	H	H	H	1	2,3	2,3	2,3
5-10 metres	M	M	M	H	1	2,3	2,3	2,3
10+ metres		L	M	M		2,3	2,3	2,3
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand		M	M	M		2	2	2
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic	H	H	H	H	3	2,3	2,3	2,3
Cover:								
None								
Submergents								
Emergents								
Overhead			*H*	H			2	2
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Emerald shiners are limnetic and form schools (2, 3).
They spawn in midwater (3), in water 2-6 m deep over clean substrate (1).
Young-of-the-year to adults are found in water < 10 m deep over sandy beaches in shelted areas (2).

Sources for Table:

1. Becker 1983.
2. Fuchs 1967.
3. Scott and Crossman 1973.

Table 14. Lacustrine habitat requirements for spottail shiner.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H		1,4	5,6	6	
1-2 metres	H	H	H		1,4	5,6	6	
2-5 metres	H	M	M	H	1,4	5,6	4,6	4
5-10 metres		M	M	H		6	4,5,6	4,5
10+ metres				H				5
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble			*H*	H			2	2
Gravel			*H*	H			2	2
Sand	H		*H*	H	4,5		2,3,5	2,3,5
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents			*M*	M			3	3
Emergents			*M*	M			3	2,3
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
The spottail shiner is present only in the far northeastern corner of BC, in Maxhamish Lake (2).
This species can be found in shallow areas that have some vegetation over sand and rock substrates (2, 3), often near open water (3).
Adult spottail shiners spawn over sand on lake shoals, and move into water 4-7 m deep after spawning (4).
Young-of-the-year may remain on the shoals (4), in water 0-8 m deep (6).
Juveniles can be found along with young-of-the-year in primarily shallow water, but to 8 m deep (6).

Sources for Table:

1. Becker 1983.
2. Cannings and Ptolemy 1998.
3. McCann 1959.
4. Peer 1966.
5. Reckahn 1970.
6. Smith and Kramer 1964.

Table 15. Lacustrine habitat requirements for northern redbelly dace.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*H*				*1*			
1-2 metres	*H*				*1*			
2-5 metres	*H*				*1*			
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt				H				4
Muck (detritus)				H				4
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents	H	*H*	*H*	H	1,2	3	3	3
Emergents								
Overhead								
In situ								
Other								

[1] Rating are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Females lay eggs over and within filamentous algae (1, 2).
Northern redbelly dace feed on algae and other vegetation (3).
They are typically found in quiet, warm water of boggy ponds, small lakes, and pools within creeks that have primarily silt and detritus bottoms (4).

Sources for Table:

1. Cooper 1935.
2. Hubbs and Cooper 1936.
3. McPhail and Lindsey 1970.
4. Scott and Crossman 1973.

Table 16. Lacustrine habitat requirements for finescale dace.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres								
1-2 metres								
2-5 metres								
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt		H	H	H		1	1	1
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents		H	H	H		1	1	1
Overhead								
In situ								
Other								

[1]Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2]Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Finescale dace are known to hybridize with northern redbelly dace (Hubbs and Brown 1929, New 1962, Legendre 1969, Das and Nelson 1989).
Finescale dace inhabit streams, ponds and small lakes in the Fort Nelson River and One Island Lake (Scott and Crossman 1973).

Sources for Table:

1. Page and Burr 1991.

Table 17. Lacustrine habitat requirements for fathead minnows.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	*H*	*H*	2,3	2,3	2	2
1-2 metres			*H*	*H*			2	2
2-5 metres			*H*	*H*			2	2
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder	H				2,3			
Rubble	H				2,3			
Cobble	H				2,3			
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)			H	H			1	1
Limnetic								
Cover:								
None								
Submergents								
Emergents	H	*H*			2,3	2,3		
Overhead								
In situ	H	*H*			2,3	2,3		
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Fathead minnow were introduced into BC (1).
Fathead minnows prefer still muddy waters in ponds and small lakes (Bendell and McNicol 1987), but are also found in muddy rivers and beaver ponds (Dymond 1956, Dymond and Scott 1941), and saline lakes (Rawson and Moore 1944, Nelson 1968a).
Nests are selected under rocks, lily pads, branches or logs in water < 1m deep (2, 3, Markus 1934).

Sources for Table:

1. McPhail and Lindsey 1970.
2. Richardson 1937.
3. Wynne-Edwards 1932.

Table 18. Lacustrine habitat requirements for northern pikeminnows.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H			H	3,5,8			2,4,6
1-2 metres	M	*H*	*H*	H	5,8	*3,8*	*8*	2,4,6
2-5 metres	M	*H*	*H*	H	5,8	*3,8*	*8*	1,2,4,6
5-10 metres	M			H	5			1,2,*4,8*
10+ metres	M			M	5			1,2,*8*
Substrate:								
Bedrock								
Boulder								
Rubble	M				5			
Cobble	M				5			
Gravel	H				5,8			
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic				L				7
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Northern pikeminnow are bottom feeders and piscivores, often found in the nearshore area of lakes (1, 2, 6, Clemens et al. 1939, Collis et al. 1995), and large rivers (Buchanan et al. 1981).
Fathead minnows prefer still muddy waters in ponds and small lakes (Bendell and McNicol 1987), but are also found in muddy rivers and beaver ponds (Dymond 1956, Dymond and Scott 1941), and saline lakes (Rawson and Moore 1944, Nelson 1968a).
Nests are selected under rocks, lily pads, branches or logs in water < 1m deep (2, 3, Markus 1934).

Sources for Table:

1. Beauchamp et al. 1995.
2. Godfrey 1955.
3. Jeppson and Platts 1959.
4. Narver 1967.
5. Patten and Rodman 1969.
6. Ricker 1952.
7. Scarsbrook and McDonald 1973.
8. Scott and Crossman 1973.

Table 19. Lacustrine habitat requirements for longnose dace.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*H*	H	H	L	2	1,2	1,4	4
1-2 metres	*H*	H	H	H	2	1,2	1,4	4,6
2-5 metres			M	H			4	4,6
5-10 metres				M				7
10+ metres				M				7
Substrate:								
Bedrock								
Boulder	H		*H*	H	2		2,6	2,6
Rubble	H		*H*	H	2		2,6	2,6
Cobble	H	H	*H*	H	2	1	2,6	2,6
Gravel	H	H	*M*	M	2	1	2,6	2,6
Sand		M	*L*	L		1	2,6	2,6
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic		H	M	M		2,5,6	3	3
Cover:								
None								
Submergents								
Emergents								
Overhead		H				2		
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Longnose dace occur in fast flowing streams and sometimes lakes (Scott and Crossman 1973).
Spawning takes place in streams in gravel riffles (4, 5, Bartnik 1970, Brown et al. 1970, McPhail and Carveth 1993b), or in lakes on wave-swept shores (1) and over boulder and cobble, and rubble substrates in shallow offhshore areas (2).
Young-of-the-year are limnetic for the first summer (2, 4, 5), then move to deeper water with swift currents (2).
In Okanagan Lake, BC, longnose dace were observed swimming in large schools in the limnetic zone (3).

Sources for Table:

1. Brazo et al. 1978.
2. Gee and Machniak 1972.
3. G. Haas personal communication.
4. Jeppson and Platts 1959.
5. McPhail and Lindsey 1970.
6. Scott and Crossman 1973.
7. Trautman 1957.

Table 20. Lacustrine habitat requirements for leopard dace.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres			H	H			1	1
1-2 metres			H	H			1	1
2-5 metres			*M*	*M*			1	1
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder			*H*	H			1	1
Rubble			*H*	H			1	1
Cobble			*H*	H			1	1
Gravel			*H*	H			1	1
Sand								
Silt			M	Nil			1	1
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents				H				1
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Adult (and presumably juvenile) leopard dace may be found in deeper, cooler waters when shallow areas get too warm, as long as there is abundant algal growth on rocks at depth (1).

Sources for Table:

1. Peden 1991.

Table 21. Lacustrine habitat requirements for speckled dace.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	M				1			
1-2 metres	M				1			
2-5 metres	M				1			
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel	H				1			
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Speckled dace are bottom feeders (Cannings and Ptolemy 1998).
They may spawn in shallow areas over gravel in lakes (1).
They species is predominately found in rivers and streams (Peden and Hughes 1984a, Cannings and Ptolemy 1998).

Sources for Table:

1. Moyle 1976.

Table 22. Lacustrine habitat requirements for redside shiner.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres			H	M			2,3	2,3,4
1-2 metres			H	M			2,3	2,3,4
2-5 metres			H	H			2,3	2,3,4
5-10 metres			H	H			2,3	2,3,4
10+ metres			M	M			2	2
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic			H	H			2,3,5	2,3,5
Cover:								
None								
Submergents								
Emergents			H	H			1,3,6	3,6
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Redside shiners spawn in tributary streams (Lindsey and McPhail 1963).
The newly hatched young-of-the-year move downstream into the lake, although their habitat use is unknown (Lindsey and McPhail 1963).
Redside shiners undergo extensive vertical diel migration, using deeper water during the day and surface water at night. They also undergo horizontal migrations from nearshore areas to limnetic areas (2).
Larger fish school in deeper water and farther offshore than smaller fish, which can be found close to shore in shallow water (3).

Sources for Table:

1. Brett and Pritchard 1946b.
2. Crossman 1959.
3. Johannes and Larkin 1961.
4. Narver 1967.
5. Scarsbrook and McDonald 1973.
6. Scott and Crossman 1973.

Table 23. Lacustrine habitat requirements for tench.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*H*		M	M	3		1	1,2
1-2 metres	*H*		M	M	3		1	1,2
2-5 metres	*H*		M	M	3		1	1,2
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand			H	H			1	1
Silt								
Muck (detritus)								
Clay (mud)			*H*	H			3	3
Limnetic								
Cover:								
None								
Submergents								
Emergents	H	*H*	*H*	*H*	3	3	3	3
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Tench were introduced to North America (Dymond 1936).
They inhabit mud-bottomed lakes, ponds and still waters in lower reaches of rivers which are heavily vegetated (3).
Spawning takes place in shallow, weedy areas of lakes (3).

Sources for Table:

1. G. Haas personal communication.
2. Jeppson and Platts 1959.
3. Scott and Crossman 1973.

Table 24. Lacustrine habitat requirements for longnose sucker.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres		*H*		L		1,4		3,8
1-2 metres		*H*	H	L		1,4	6	3,6,8
2-5 metres		*H*	H	H		1,4	6	3,5,6,8
5-10 metres			H	H			6	3,5,6,8
10+ metres			H	H			6	2,3,5,6,9,10
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand		H	H	H		5	5	5
Silt								
Muck (detritus)								
Clay (mud)		H	H	H		5	5	5
Limnetic								
Cover:								
None								
Submergents								
Emergents		H	H			1,4	5	
Overhead								
In situ				M				7
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Tench were introduced to North America (Dymond 1936).
They inhabit mud-bottomed lakes, ponds and still waters in lower reaches of rivers which are heavily vegetated (3).
Spawning takes place in shallow, weedy areas of lakes (3).

Sources for Table:

1. Brown and Graham 1953.
2. Clemens et al. 1939.
3. Dryer 1966.
4. Edwards 1983.
5. Emery 1973.
6. Libosvarsky 1970.
7. Moring et al. 1986.
8. Narver 1967.
9. Rawson 1951.
10. Scott and Crossman 1973.

Table 25. Lacustrine habitat requirements for white sucker.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*H*	M	H	H	10	2,7,8,13	5,7,11	3,5,7,8,11
1-2 metres	*H*	*M*	H	H	10	2,8,13	5,7,11	3,4,6,8,11,12
2-5 metres	*H*	*L*	H	H	10	2,8,13	1,6,11	1,3,6,8,11,12
5-10 metres			L	H			1	1,2,8,12,13
10+ metres			L	H			1,11	3,8,11,12,13
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel	*H*				13			
Sand								
Silt								
Muck (detritus)			*M*	*M*			8	8
Clay (mud)								
Limnetic		M				8		
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ				M				4,9
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
White suckers inhabit warm, shallow water in lakes and tributary streams (3, 5, 6, 7, 11, 13).
Some spawning takes place along lake margins (10).
White suckers have been found to school with young spottail shiners, yellow perch and sticklebacks (13).
Young-of-the-year are limnetic for their first summer, after which they become benthic (8).
Juvenile and adult white suckers are completely benthic, and may geed over detritus (8).

Sources for Table:

1. Berst and McCombie 1963.
2. Corbett and Powles 1983.
3. Emery 1973.
4. Hubert and Rahel 1989.
5. Johnson 1977.
6. Kelso 1974.
7. Lyons 1987.
8. McPhail and Lindsey 1970.
9. Moring et al. 1986.
10. Nelson 1968c.
11. Rawson 1951.
12. Reckahn 1970.
13. Scott and Crossman 1973.

Table 26. Lacustrine habitat requirements for largescale sucker.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*L*	*H*	*H*	H	3	1	1,3	3
1-2 metres	*L*	*H*	*H*	H	3	1	1,3	3
2-5 metres		*H*	*H*	H		1	1,3	3
5-10 metres			*H*	M			3	3,4
10+ metres			*M*	M			3	3,4
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand	L				2			
Silt								
Muck (detritus)								
Clay (mud)			*H*	H			3,5,6	3,5,6
Limnetic		H				3,6		
Cover:								
None								
Submergents				H				3
Emergents		*H*	H	H		1	1	3
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Largescale suckers are commonly found in weedy areas of lakes associated with the bottom, in backwaters and in stream mouths in water < 15 m deep (1, 6).
Spawning usually takes place in streams (2), but may take place in shallow margins of lakes (3).
Young-of-the-year are limnetic for the first summer, then move to the bottom and begin to feed on benthic organisms (3).
Older young-of-the-year to adults are benthic feeders (3, 5), and may feed on fish eggs (4).
Young-of-the-year and juveniles feed in very shallow water during the day and move to deeper water at night (3).

Sources for Table:

1. Clemens et al. 1939.
2. Nelson 1968c.
3. McPhail and Lindsey 1970.
4. Patten and Rodman 1969.
5. Ricker 1952.
6. Scott and Crossman 1973.

Table 27. Lacustrine habitat requirements for black bullhead.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*H*	*H*			1	1		
1-2 metres	*H*	*H*			1	1		
2-5 metres	*H*	*H*			1	1		
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel	H	H			1	1		
Sand								
Silt	H	H	*H*	H	1	1	1	1
Muck (detritus)	H	H			1	1		
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents	H	H			1	1		
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Black bullheads were introduced to the Columbia River in Washington State, and have since spread into Oregon and BC (1).
Black bullheads are benthic feeders and are found in the lower section of low gradient, small to medium sized streams, slow backwaters of large rivers, and silty bottomed areas of lakes and ponds (1).
Nest are built during spawning in shallow, vegetated areas over gravel, silt and detritus (1).

Sources for Table:

1. Scott and Crossman 1973.

Table 28. Lacustrine habitat requirements for brown bullhead.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	*H*	H	2	2	2	2
1-2 metres	H	H	*H*	H	2	2	2	1,2
2-5 metres	H	H	*H*	H	2	2	2	1,2
5-10 metres				H				2
10+ metres				H				2
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand	H	*H*	*H*	H	2	2	2	2
Silt								
Muck (detritus)								
Clay (mud)	H	*H*	*H*	H	2	2	2	2
Limnetic								
Cover:								
None								
Submergents			*H*	H			2	2
Emergents	H	H	*H*	H	2	2	2	2
Overhead	H	H			2	2		
In situ	H	H			2	2		
Other	H	H			2	2		

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Brown bullheads were introduced to BC (1).
Brown bullheads are benthic, and are typically found in shallow to deep water in ponds, small lakes, and bays of large lakes, as well as large, slow-moving rivers that have abundant aquatic vegetation (1, 2).

Sources for Table:

1. Kelso 1974.
2. Scott and Crossman 1973.

Table 29. Lacustrine habitat requirements for northern pike.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H	H	3,9,10,14,18	3,10,13,14,18	3,10,14	3,7,10,11,18
1-2 metres	H	H	H	H	9,10,11	3,10,13,14,18	3,10,14,15	3,6,7,10,11,15,18
2-5 metres		L	M	H	16	3,13,17,18	3,15,17	3,6,7,10,11,15,17,18
5-10 metres		L	L	L	16	17	3,17	3,6,7,15,17,18
10+ metres		L	L	L		17	3,17	3,7,17,18
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand		M	Nil	Nil	12	12	8	8
Silt		H	H	H	12,18	10,12	10	10
Muck (detritus)	M	H			3,12,18	3,4,10,12	4,10	3,7,10
Clay (mud)		H	H	H	3	3,4,10	4,10	10
Limnetic		L	L	L		17	17	4,5,6,10,17
Cover:								
None								
Submergents	H	H	H	M	3,10,18	1,3,4,10,12	2,3,4,10	3,6,7,10,16
Emergents	H	M			3,18,19	1,3,4,12	2,4	7
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Northern pike spawn in shallow, densely vegetated areas in bays of lakes and marshes (3, 10, 18).
Typically, they inhabit lakes where the majority of the surface area is within the shallow littoral zone (10).
Adults and juveniles avoid areas that are dominated by sand substrate (8).

Sources for Table:

1. Anderson 1993.
2. Bragazzi and Kennedy 1980.
3. Casselman and Lewis 1996.
4. Chapman and MacKay.1984a.
5. Chapman and MacKay 1984b.
6. Cook and Bergenson 1988.
7. Diana et al. 1977.
8. Eklov 1997.
9. Fabricius and Gustafson 1958.
10. Ford et al. 1995.
11. Hokanson et al. 1973.
12. Holland and Huston 1984.
13. Houde and Forney 1970.
14. June 1970.
15. Libosvarsky 1970.
16. Randall et al. 1996.
17. Rawson 1951.
18. Scott and Crossman 1973.
19. Threinen et al. 1966.

Table 30. Lacustrine habitat requirements for rainbow smelt.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	M	L	L	2,5,6	3,4	3,4	3,4
1-2 metres	H	H	L	L	2,5,6	3,4	3,4	3,4
2-5 metres	H	H	M	L	2,5,6	3,4	3,4	3,4
5-10 metres		H	H	L		3,4	3,4	3,4
10+ metres		H	H	H		1,3,4	1,3,4	1,3,4
Substrate:								
Bedrock								
Boulder	H				2,5			
Rubble	H				2,5,6			
Cobble	H				2,5,6			
Gravel	H				2,5,6			
Sand	H				2,5,6			
Silt	H				2,5			
Muck (detritus)	H				2,5			
Clay (mud)	H				2,5			
Limnetic								
Cover:								
None								
Submergents								
Emergents	H				2,5			
Overhead								
In situ	H				2,5			
Other								

[1]Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2]Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
There is virtually one freshwater record of rainbow smelt in BC, occuring in the Stikine River (G. Haas personal communication., Haas 1998).
Rainbow smelt are both anadromous and freshater resident (Scott and Crossman 1973, Scott and Scott 1988).
In lakes, rainbow smelt spawn in shallow bays and shores (5, 6, Burgess 1978).
They spawn over a variety of substrates, and near vegetation and submerged logs (2, 5, 6).

Sources for Table:

1. Berst and McCombie 1963.
2. Bradbury et al. 1999.
3. Dryer 1966.
4. Emery 1973.
5. Ivanova and Polovkova 1972.
6. Morrow 1980.

Table 31. Lacustrine habitat requirements for pygmy longfin smelt.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres								
1-2 metres								
2-5 metres								
5-10 metres		*H*	*H*	H		1	1	1
10+ metres		*H*	*H*	H		1	1	1
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic		H	H	H		1	1	1
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Pygmy longfin smelt are found in Pitt and Harrison lakes, BC (1, McPhail and Carveth 1993b).
Spawning location is unknown, but spawning is thought to take place during the winter (1).
Pygmy longfin smelt inhabit deep water (1).

Sources for Table:

1. Cannings and Ptolemy 1998.

Table 32. Lacustrine habitat requirements for cisco.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H	M	3	1,5,6	1,5,6	1,3,5,7,8
1-2 metres	H	H	H	M	3	1,5,6	1,5,6	1,3,5,7,8
2-5 metres	H	H	H	H	3	1,5,6	1,2,5,6	1,5,6,7,8
5-10 metres	M	H	H	H	9	1,5,6	1,2,4,5,6	1,4,5,6,7,8
10+ metres	M	H	H	H	9	1,5,6	1,3,4,5,6	1,4,5,6,7
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel	H				3,6			
Sand	H				6			
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic	M	H	H	H	3	6	6,9	6,9
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Ciscos inhabit only Maxahamish Lake in BC (3).
Maxhamish Lake is relatively shallow compared to other lakes in which ciscos are found (3).
In Ontario Lakes, ciscos are caught at depths between 0-16- m (5, 9).
Young-of-the-year and juvenile ciscos remain in shallow wter, except during the summer when water temperatures increase (4, 5).
Spawning is in water 1-3 m deep over sand and gravel substrates (6, 9).

Sources for Table:

1. Aku and Tonn 1997.
2. Aku et al. 1997.
3. Cannings and Ptolemy 1998.
4. Emery 1973.
5. Ferguson 1958.
6. McPhail and Lindsey 1970.
7. Rawson 1951.
8. Reckahn 1970.
9. Scott and Crossman 1973.

Table 33. Lacustrine habitat requirements for lake whitefish.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H		M	1,3,6,9	5,12,13		1,7,11
1-2 metres	H	H	H	H	1,3,6,9	5,8,12	8	1,7,8,10,11
2-5 metres	H	H	H	H	1,3,6,9	5,8,12	8	1,7,8,10,11,12
5-10 metres	H	H	H	H	1,9	8	8	1,7,8,10,11,12
10+ metres	M	H	H	H	9	5,8,13	6,8,13	4,6,7,8,10,12,13
Substrate:								
Bedrock								
Boulder	H			M	3,9			1
Rubble	*H*		*H*	*H*	3,9		6	1
Cobble	H		H	H	3,6,9		6	1
Gravel	H		H		3,6,9		6	
Sand	M				2,9			
Silt	L				2,3			
Muck (detritus)				M				1
Clay (mud)	Nil				6			
Limnetic		H				6		
Cover:								
None								
Submergents			H				6	
Emergents	M	H	H		3	13	6	
Overhead								
In situ			H				6	
Other				H				6

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Lake whitefish are native to the northern region of BC, but have been introduced to the Fraser and Columbia river drainages (6, Carl et al. 1959).
Spawning in small lakes is generally in water < 10 m deep (1, 3, 6, 9, Ayles 1976, Morrow 1980).
Young-of-the-year remain in shallow water during the spring, but quickly move to deeper water when temperatures start to increase, and continue to descend with the onset of winter (13).
Young-of-the-year are intially limnetic feeders, but transform to benthic living within the first year (6).
Adult lake whitefish use dark areas as cover (6).

Sources for Table:

1. Begout Anras et al. 1999.
2. Bidgood 1972.
3. Bryan and Kato 1975.
4. Dryer 1966.
5. Faber 1970.
6. Ford et al. 1995.
7. Godfrey 1955.
8. Libosvarsky 1970.
9. Machniak 1975.
10. McHugh 1939.
11. Narver 1967.
12. Rawson 1951.
13. Reckahn 1970.

Table 34. Lacustrine habitat requirements for broad whitefish.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres		H	H			1	1	
1-2 metres		H	H			1	1	
2-5 metres		H	H			1	1	
5-10 metres		H	H	H		1	1	1
10+ metres		H	H	H		1	1	1
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic		*H*	*H*	*H*		1	1	1
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Most of the information pertaining to broad whitefish comes from Asian studies.
Young broad whitefish were found within the top few meters of water while the adults ranged between 5-20 m depths in the Bay of Bothnia, Central Baltic (1).
Spawning takes palce in streams (McPhail and Lindsey 1970).

Sources for Table:

1. Valtonen 1970.

Table 35. Lacustrine habitat requirements for least cisco.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*H*	*H*			*1*	*1*		
1-2 metres	*H*	*H*			*1*	*1*		
2-5 metres	*H*	*H*			*1*	*1*		
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel	H	*H*			1	1		
Sand	H	*H*			1	1		
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic			*M*	*M*			*1*	*1*
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
In BC, least ciscos are only found in Atlin, Teslin and Swan lakes within the Yukon River drainage (1).
They spawn along lake shores over sand and gravel substrates (1).
Least cisco feed on plankton and insect larvae, so presumably they occur in the limnetic zone (1).

Sources for Table:

1. Cannings and Ptolemy 1998.

Table 36. Lacustrine habitat requirements for cutthroat trout.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres		M	M	H		2	2	1,2,3,4,6
1-2 metres		M	M	H		2	2	1,2,3,4,6
2-5 metres			H	H			5	1,3,4,5,6
5-10 metres			H	H			5	1,3,5
10+ metres			L	L			5	5
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand		M				2		
Silt		M				2		
Muck (detritus)		M				2		
Clay (mud)								
Limnetic			H	H			3	3
Cover:								
None								
Submergents								
Emergents		M				2		
Overhead								
In situ		M				2		
Other		M	H	H		2	6	6

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Lacustrine populations of coastal cutthroat trout are often found in sympatry with other salmonids (1, 3).
When in allopatry, this species used the whole lake environment (3).
It is thought that they will use the entire lake if there is no competition for resources (Ford et al. 1995).
Cutthroat trout spawn and rear in tributary streams (Irving 1954, Shapley 1961, Liknes and Graham 1988, Northcote and Hartman 1988).

Sources for Table:

1. Andrusak and Northcote 1971.
2. Bryant et al. 1996.
3. Nillson and Northcote 1981.
4. Pierce 1984.
5. Schutz and Northcote 1972.
6. Shepherd 1974.

Table 37. Lacustrine habitat requirements for coho salmon.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres		*H*	H			1	2,4,5	
1-2 metres		*H*	H			1	2,4,5	
2-5 metres		*H*	M			1	2,4	
5-10 metres			L				2,5	
10+ metres			L				2	
Substrate:								
Bedrock								
Boulder								
Rubble		M	M			1	1	
Cobble		M	M			1	1	
Gravel		M	M			1	1	
Sand		M	M			1	1	
Silt		M	M			1	1	
Muck (detritus)								
Clay (mud)								
Limnetic			M				2,3	
Cover:								
None		M	M			1	1	
Submergents		M	M			1	1	
Emergents		M	M			1	1	
Overhead								
In situ		M	M			1	1	
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Young-of-the-year and juvenile coho salmon will rear in lakes (1, 2, Foerster and Ricker 1953, Bragham and Adams 1954, Peterson 1982, Swales et al. 1987).
Juvenile (and presumably young-of-the-year) will utilize the shallow areas of small lakes (3).
Young-of-the-year and juvenile coho salmon will use lakes as overwintering areas if their natal streams do not have adequate overwintering habitat (Tshaplinski and Hartman 1983).

Sources for Table:

1. Bryant et al. 1999.
2. Ruggerone and Rogers 1992.
3. Scarsbrook and McDonald 1973.
4. Scott and Crossman 1973.
5. Simpson et al. 1981.

Table 38. Lacustrine habitat requirements for rainbow trout.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H	H	8,9	13,14	4,5,7,13	1,2,4,5,7
1-2 metres	H	H	H	H	8,9	13,14	4,5,7,13	1,2,4,5,7
2-5 metres	L	H	H	H	9	9	3,4,5,7,9	1,2,4,5,7
5-10 metres		L	H	M		9	4,7,9	1,2,4,7
10+ metres				M				1,2,4
Substrate:								
Bedrock								
Boulder				H				1,9
Rubble	H	H	H	H		9,13	9,13	9
Cobble	H	H	H	H		9,13	1,9,13	1,9
Gravel	H	L	L		8,9	13	13	
Sand	H	L	L	L		13	1,9,13	1
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic		M	L	L		12,13	10,11	6,7,10,11
Cover:								
None								
Submergents	L	L	L	L	8	13	12,13	12
Emergents	L	L	L	L	8	13	12,13	12
Overhead								
In situ		H	H	H		9,13	9,13	9
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Typically, rainbow trout spawn in inlet and outlet streams (3, Lindsey et al. 1959, Scott and Crossman 1973).
They will spawn on lake shores over gravel substrate (8, 9).
When in allopatry, rainbow trout were found in shallow areas, but in sympatry they were found at depths between 5-6 m (7).
Rainbow trout are primarily found in shallow littoral areas (4).
Occasionally, rainbow trout associate with aquatic vegetation (8, 12, 13).

Sources for Table:

1. Beauchamp et al. 1994.
2. Crossman 1959.
3. Ford et al. 1995.
4. Graynoth 1999.
5. Jeppson and Platts 1959.
6. Levy et al. 1991.
7. Nilsson and Northcote 1981.
8. Penlington 1983.
9. Raleigh et al. 1994.
10. Scarsbrook and McDonald 1973.
11. Scarsbrook and McDonald 1975.
12. Scott and Crossman 1973.
13. Tabor and Wurtsbaugh 1991.
14. Wurtsbaugh et al. 1975.

Table 39. Lacustrine habitat requirements for sockeye salmon.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	M	L	7,10,12,17	3,4,11,14,17,18	8,18	18
1-2 metres	H	H	M	L	7,10,12,17	3,4,14,17,18	8,18	18
2-5 metres	H	H	M	L	2,4,12,17	2,4,14,15,17,18	2,8,18	18
5-10 metres	M	M	H		2,4	1,2,14,15,19	2,8,18	
10+ metres	M	M	H		2,16	2,5,14,15,19	2,8,13,19	
Substrate:								
Bedrock								
Boulder								
Rubble	H				6,12			
Cobble								
Gravel	H	M			4	3		
Sand	L	L			16	3		
Silt		M				3		
Muck (detritus)		L				3		
Clay (mud)								
Limnetic		H	H			9,14,18,19	8,18,19	
Cover:								
None								
Submergents								
Emergents		M				3		
Overhead								
In situ								
Other		M				3		

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
In lakes, sockeye salmon will spawn from 30 m over coarse sand, to shallow beaches (7, 12, 16).
Adult sockeye salmon were caught in shallow water in Babine Lake (18).

Sources for Table:

1. Barraclough and Robinson 1972.
2. Beauchamp et al. 1995.
3. Bryant et al. 1996.
4. Burgner 1991.
5. Dawson et al. 1973.
6. Foerster 1968.
7. Forskett 1947.
8. Goodlad et al. 1974.
9. Heard 1965.
10. Hendry and Quinn 1997.
11. Johnson 1956.
12. Kerns and Donaldson 1968.
13. Levy et al. 1991.
14. Morton and Williams 1990.
15. Nunnallee and Mathisen 1974.
16. Olsen 1968.
17. Ruggerone and Rogers 1992.
18. Scarsbrook and McDonald 1973.
19. Simpson et al. 1981.

Table 40. Lacustrine habitat requirements for kokanee.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H	H	2	4	2,4	2,3
1-2 metres		H	H	H		4	2,4	2,3
2-5 metres		H	H	H		1,4	1,2,4	2,3
5-10 metres		H	H	H		1,4	1,2,4	2,3
10+ metres		H	H	H		1,4	1,2,4	2,3
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble	H		H		2		2	
Gravel	H		H		2,5		2	
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic		H	H	H		1,5	1,2,3,4,5	1,2,3,4,5
Cover:								
None								
Submergents								
Emergents								
Overhead			H				2	
In situ			H				2	
Other				H				2

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Kokanee undergo diel vertical migration. At night kokanee are in shallower water near the surface, while during the day they frequent deeper water (2, 3, 4).
Kokanee spawn in lake tributaries or on lake beaches over gravel or cobble substrate (2, Scott and Crossman 1973, Burgner 1991).
Adult kokanee use darkness as cover (2).

Sources for Table:

1. Beauchamp et al. 1995.
2. Ford et al. 1995.
3. Levy 1991.
4. Narver 1970.
5. Scott and Crossman 1973.

Table 41. Lacustrine habitat requirements for chinook salmon.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*H*	L	H		2	1	1	
1-2 metres	*H*	L	H		2	1	1	
2-5 metres	*H*	M	H		2	1	1	
5-10 metres		M				1		
10+ metres		L				1		
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel	H				2			
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic			L				3	
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Chinook salmon are primarily a river-dwelling species, however some lake-dwelling populations exist (1, 2).
In lakes, spawning may take place on gravel shores probably at depths similar to river spawning populations (2, Chapman 1943).

Sources for Table:

1. Graynoth 1999.
2. Scott and Crossman 1973.
3. Simpson et al. 1981.

Table 42. Lacustrine habitat requirements for pymgy whitefish.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H			L	2			2
1-2 metres	H			L	2			2
2-5 metres	H			L	2			2
5-10 metres				H				2
10+ metres				H				1,2
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel	*H*				2			
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Pygmy whitefish inhabit mountain lakes and clear or silted rivers (2).
Typically, they are found in water > 7 m deep (2).
Eggs are laid over coarse gravel substrate (2).

Sources for Table:

1. Dryer 1966.
2. Scott and Crossman 1973.

Table 43. Lacustrine habitat requirements for giant pygmy whitefish.

Habitat Features:	Ratings[1] giant				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*H*				1			
1-2 metres	*H*				1			
2-5 metres	*H*		*H*	H	1		1	1
5-10 metres			*H*	H			1	1
10+ metres			*H*	H			1	1
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel	*H*				1			
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Giant pygmy whitefish occur in two lakes in BC, Tyhee and McLeese lakes (Cannings and Ptolemy 1998), in deeper water than pygmy whitefish (1).
Very little information is available for this subspecies, however spawning habitat is assumed to be similar to pygmy whitefish (1).
Lack of competition with other whitefish species is thought to be the cause of the divergence in size in these populations of pygmy whitefish (1).

Sources for Table:

1. McCart 1965.

Table 44. Lacustrine habitat requirements for round whitefish.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	*H*		1,3	4	4	
1-2 metres	H	*H*	*H*		1,3	4	4	
2-5 metres	M	*H*	*H*		5	4	4	
5-10 metres	M	*H*	*H*		5	4	4	
10+ metres	M			H	5			2,4
Substrate:								
Bedrock								
Boulder	H				1,3			
Rubble	H				3			
Cobble	H				1			
Gravel	H				1,3,5			
Sand	L				1,3			
Silt	M				1			
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents	M				1			
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Round whitefish are bottom feeders that inhabit the bottom of deep and shallow lakes (2, 5).
Spawning is in primarily shallow water, but spawning in 16 m of water has been observed (1, 2, 5).
The data presented in (4), suggests that young-of-the-year and juvenile round whitefish inhabit water < 10 m deep.

Sources for Table:

1. Bryan and Kato 1972.
2. Dryer 1966.
3. Normandeau 1969.
4. Rawson 1951.
5. Scott and Crossman 1973.

Table 45. Lacustrine habitat requirements for mountain whitefish.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	H	H	1	1	2,3,4	2,4,5,7
1-2 metres			H	H			2,3,4	2,3,4,6,7
2-5 metres			M	H			2,3,4	2,3,4,6,7,8
5-10 metres	L		L	H	3		2	2,3,6,7,8
10+ metres	L		L	H	3		2	2,3,6,8
Substrate:								
Bedrock								
Boulder								
Rubble	H				8			
Cobble	*H*				1,7,8			
Gravel	H				1,7			
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic			*L*	L			5,6,9	5,6,9
Cover:								
None								
Submergents			H	L			1,3	1
Emergents								
Overhead			L	L			1	1
In situ			L	L			1	1
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
A population with two unique forms of mountain whitefish exists in Kootenay Lake, BC (McPhail and Carveth 1993b).
Within 'normal' populations, mountain whitefish are benthic feeders, but will feed throughout the water column if an adequate supply of food is not available on the bottom (6).
Inhabit clear or silty lakes (6), and large streams (1, 7).
Spawning takes place along shallow lake shores over gravel and rubble substrate (6, 7).

Sources for Table:

1. Ford et al. 1995.
2. Godfrey 1955.
3. Hagen 1970.
4. Jeppson and Platts 1959.
5. Levy et al. 1991.
6. McHugh 1939.
7. McPhail and Lindsey 1970.
8. Scott and Crossman 1973.
9. Simpson et al. 1981.

Table 46. Lacustrine habitat requirements for Atlantic salmon.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres		H	H			6,8,9	3,4,7,9,10,11	
1-2 metres		H	H			8	2,3,4,7,9,10,11	
2-5 metres		H	M			8	2,3,4,7,910	
5-10 metres			L				4,5,7,9	
10+ metres			L				5,8	
Substrate:								
Bedrock								
Boulder								
Rubble		H	H			6,8,9	3,4,6,8,9,10	
Cobble		H	H			6,8,9	3,4,6,8,10,11	
Gravel		L	M			8	8,11	
Sand		L	L			8	4,8	
Silt		L				8		
Muck (detritus)								
Clay (mud)								
Limnetic			L-M				2,7,8,10	
Cover:								
None								
Submergents			L				1,3,4,11	
Emergents			L				1,3,4,11	
Overhead								
In situ			H				3,4	
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Information in this table comes primarily form Bradbury et al. 1999.
Anadromous populations exist in BC that threaten native salmon populations (Gross 1998).
Although they may exist, it is unlikely that any lake-dwelling populations, like those on the east coast, have become established in BC lakes (G. Haas personal communication., J. Volpe, Department of Biology and Centre for Environmental Health, University of Victoria, BC, personal communication.).

Sources for Table:

1. Arnemo 1975.
2. Dempson and O'Connell 1993.
3. Halvorsen and Jorgensen 1996.
4. Halvorsen et al. 1997.
5. Hindar and Jonsson 1982.
6. Hutchings 1986.
7. O'Connell and Ash 1989.
8. O'Connell and Dempson 1990.
9. O'Connell and Dempson 1996.
10. Pepper et al. 1985.
11. Sutton 1994.

Table 47. Lacustrine habitat requirements for brown trout.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H	L	4,11	*1,2,9,10*	*1,2* ,5,6,7,8,9,10,13	5,10,13,14
1-2 metres	H	H	H	L	4,11	*1,2,9,10*	*1,2* ,5,6,7,8,9,10,13	5,10,13,14
2-5 metres		L	H	L		3,9,10	5,6,7,8,9,10,13	5,10,13,14
5-10 metres		L	M	H		3	8,9,10	5,14
10+ metres		L	L	H		3	8,9	5,14
Substrate:								
Bedrock								
Boulder				H				13
Rubble	H	H	H	H	3,4,11	7	5,7,13	13
Cobble	H	H	H		3,4,11	1,2,7	1,2,5,7	
Gravel	H	*M*	*M*		4,11,12	7	2,5,7	
Sand		*M*	M			7	7	
Silt				M				5
Muck (detritus)				*M*				5
Clay (mud)				M				5
Limnetic			L	M			9,13	5,6,7,8,9,13,14
Cover:								
None								
Submergents		*L*	L			*9*	1,9	
Emergents			L				1	
Overhead								
In situ		*H*	H			*9*	5,9	
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Brown trout spawn in streams or lake shores over gravel and rocky substrates (3, 4, 11, 12).
Juvenile brown trout occur in shallower water than adults (13, 14).

Sources for Table:

1. Arnemo 1975.
2. Borgstroem et al. 1993.
3. Daly 1968.
4. Eddy and Surber 1960.
5. Haraldstad and Jonsson 1983.
6. Hegge et al. 1989.
7. Hegge et al. 1993a.
8. Hegge et al. 1993b.
9. Jonsson and Gravem 1985.
10. Jorgensen et al. 1996.
11. Liew 1969.
12. Matthews et al. 1997.
13. O'Connell and Dempson 1996.
14. Schei and Jonsson 1989.

Table 48. Lacustrine habitat requirements for bull trout.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres			*H*	H			1	1
1-2 metres			*H*	H			1	1
2-5 metres			*H*	H			1	1
5-10 metres			*H*	H			1	1
10+ metres			*H*	H			1	1
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information
[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Lacustrine populations of bull trout inhabit large, oligotrophic, high altitude lakes (McPhail and Baxter 1996).
Bull trout feed in the littoral zone during the fall and spring, and move into deep water during the summer (1).
Bull trout spawn in tributary streams (Carl et al. 1989, Fraley and Shepard 1989, Cannings and Ptolemy 1998).

Sources for Table:

1. Goetz 1989.

Table 49. Lacustrine habitat requirements for brook trout.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H	H	3,4,5,11	1,3,6,13,14	1,7,10,13,14	1,2,3,10
1-2 metres	H	H	H	H	3,10,14	1,3,6,13,14	1,7,10,13,14	1,3,10,13
2-5 metres	H	H	H	H	13	1,6,13	1,7,10,13	1,3,7,10,13
5-10 metres	H	L	M	M	13	1,6,13	1,7,10,13	1,3,7,10,13
10+ metres			L	L			10	10
Substrate:								
Bedrock								
Boulder								
Rubble		H	H			8	8	
Cobble	M	H	H	H	1,5	3,8	3,8	3
Gravel	H	H	H	H	1,3,5,14	3	3,8	3
Sand	M			L	1,3,5,6			2
Silt	L			L	1,5,12			2
Muck (detritus)	L				4,12			
Clay (mud)	L				4			
Limnetic			L	L			7,10	7,10,13
Cover:								
None								
Submergents		H	H	H		7,8	7,8	9
Emergents			H	H		7,8	7,8	9
Overhead		H		H		14		3
In situ	L	H	H	H	4	7,14	8	3
Other	H				3			

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Spawning takes place during summer and fall (3, Scott and Crossman 1973).
Spawning in lakes takes place near cold water springs (3, 14).

Sources for Table:

1. Bradbury et al. 1999.
2. Chiselhomn et al. 1987.
3. Ford et al. 1995.
4. Fraser 1982.
5. Fraser 1985.
6. Gloss et al. 1989.
7. Halvorsen et al. 1996.
8. Hosn and Downing 1994.
9. Lacasse and Magnan 1992.
10. O'Connell and Dempson 1996.
11. Quinn 1995.
12. Snucins et al. 1992.
13. Venne and Magnan 1995.
14. Wurtsbaugh et al. 1975.

Table 50. Lacustrine habitat requirements for Dolly Varden.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres			*L*	L			1,2,3	1,2,3
1-2 metres			*M*	M			1,2,3	1,2,3
2-5 metres			*H*	H			1,2,3	1,2,3
5-10 metres			*H*	H			1,2,3	1,2,3
10+ metres			*M*	M			1,2	1,2
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic			M	M			1,2,3	1,2,3
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1]Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2]Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
There are anadromous and freshwater populations of Dolly Varden (Scott and Crossman 1973).
Freshwater resident populations are usually stream resident, but lake-dwelling populations do exist (1, 2, Ricker 1942).
In sympatry with cutthroat trout, Dolly Varden are found offshore on the bottom to mid-column (1, 2).

Sources for Table:

1. Andrew et al. 1992.
2. Andrusak and Northcote 1971.
3. Schutz and Northcote 1972.

Table 51. Lacustrine habitat requirements for lake trout.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	M	H			3,9	2		
1-2 metres	M		H	M	3,9		4	4
2-5 metres	H		H	H	3,9		4	4
5-10 metres	H		H	H	3,9		4	4
10+ metres	H	H	H	H	3,9	2,7	3,4	1,3,4,5
Substrate:								
Bedrock								
Boulder								
Rubble	H	H			3,9		3	
Cobble	H	H			9		3	
Gravel	H				9			
Sand	M				9			
Silt								
Muck (detritus)	Nil				6			
Clay (mud)	Nil				6			
Limnetic		*H*	*H*	H		3	3,8	3,8
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ			H				3	
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Lake trout inhabit large, deep, clear, cold lakes (1, 5, Rawson 1951, Johnson et al. 1977, Marin and Olver 1980).
Lake trout are limnetic (3, 8, Levy et al. 1991).
Lake trout spawn at various depths depending on lake size and amount of suitable substrate (3).
Lake trout can be found at great depths (185 m in Lake Superior, 9).

Sources for Table:

1. Dryer 1966.
2. Eschmeyer 1955.
3. Ford et al. 1995.
4. Libosvarsky 1970.
5. Loftus 1957.
6. Martin 1956.
7. Royce 1951.
8. Scarsbrook and McDonald 1973.
9. Thibodeau and Kelso 1990.

Table 52. Lacustrine habitat requirements for inconnu.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres			*H*	H			1,2	1,2
1-2 metres			*H*	H			1,2	1,2
2-5 metres			*H*	H			1,2	1,2
5-10 metres			*H*	H			1,2	1,2
10+ metres			*L*	L			1,2	1,2
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt			*H*	H			1	1
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
In BC, inconnu are only found within Teslin Lake in the Yukon River drainage, and the Muskwa River in the Liard River drainage (McPhail and Carveth 1993a).
Spawning takes place in rivers, and young-of-the-year remain in the stream for up to two years (Scott and Crossman 1973).

Sources for Table:

1. Fuller 1955.
2. Rawson 1951.

Table 53. Lacustrine habitat requirements for Arctic grayling.

Habitat Features:	**Ratings[1]**				**Sources[2]** **Sources**			
Categories[3]	S	Y	J	A	S	Y	J	A
Categories[2]								
0-1 metres			*H*	H			1,3	2,3
1-2 metres			*H*	H			1,3	2,3
2-5 metres			*H*	H			3	2,3
5-10 metres			*H*	H			3	2,3
5-10 metres								
10+ metres								
Bedrock								
Boulder								
Rubble				H				2,3
Cobble				H				1,2,3
Gravel				H				2,3
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Pelagic								
Limnetic								
None								
Submergents								
Emergents								
Overhead								
In situ			M	M			2	2
Other					2			

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Arctic grayling typically inhabit clear water of large, cold rivers, smaller rocky streams, and lakes (4).
Spawning occurs in streams and rivers (Scott and Crossman 1973).
Often adults and juveniles will overwinter in the lake (2).
Arctic grayling in Great Slave Lake were caught in water < 10 m deep over rocky substrate (3).

Sources for Table:

1. Clark 1994.
2. Ford et al. 1995.
3. Rawson 1951.

Table 54. Lacustrine habitat requirements for trout-perch.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	*M*	M	6	6	2,3	2,3
1-2 metres	H	H	*M*	M	6	6	2,3	2,3
2-5 metres		*H*	*M*	M		4	2,3	2,3
5-10 metres		*H*	*M*	M		4	1,2	1,2
10+ metres		*H*	*H*	H		4	1,2,3,5,6	1,2,3,5,6
Substrate:								
Bedrock								
Boulder			*H*	H			3	3
Rubble								
Cobble								
Gravel								
Sand			*H*	H			3	3
Silt								
Muck (detritus)								
Clay (mud)			*H*	H			3	3
Limnetic								
Cover:								
None								
Submergents								
Emergents			*H*	H			3	3
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information
[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Trout-perch form spawning aggregates in June and July (6).
Young-of-the-year move to deeper water off the spawning sites (4).
Adults inhabit a range of depths from 0-70 m (1, 2, 3, 5, 6).
Presumably juvenile trout-perch occupy similar habitat as the adults.

Sources for Table:

1. Dadswell 1972.
2. Dryer 1966.
3. Emery 1973.
4. Magnuson and Smith 1963.
5. Morrow 1980.
6. Reckahn 1970.

Table 55. Lacustrine habitat requirements for burbot.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H		5,6,10,13,14,17	5,6,9,10,17,19	6,9,17,19	
1-2 metres	H	H	H		5,6,10,11,13,14,17	5,6,9,10,17,19	6,9,17,19	
2-5 metres	H	H	H	L	5,6,11,14,17	5,6,9,10,17,19	6,9,17,19	9,17,18,19
5-10 metres	L	L	L	L	5,14,17	5,6,10	6	6,9,17,18
10+ metres	L	L	L	H	13,14,17	6,10	6	3,4,6,9,14,15,17
Substrate:								
Bedrock								
Boulder				H				4,6
Rubble	H	H	H	H	10	6,9,17	6,9,17,19	4,6
Cobble	H	H	H	H	6,10,11,14,18	6,9,17,19	6,9,17,19	6
Gravel	H	H	H	H	1,6,10,11,14,17,18	6,9,19	6,9	6
Sand	H			H	6,10,14,17,18	8,17	17	4,6
Silt	L			L	6,14,18			6
Muck (detritus)	L				6,14,18			
Clay (mud)	Nil				6,14,18			
Limnetic		H				2,7,10,16		
Cover:								
None								
Submergents		M	M	M		6,8,12,17,19	6,12,17	4
Emergents		M	M	M		12	12	4
Overhead		M	M	M		6,8	6	4
In situ		M	M	M		6,8,12	6,12	4
Other				M				6

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Burbot are primarily a benthic lake species, but they are also found in streams (Porter and Rosenfeld 1999).
Young-of-the-year are limnetic for a short time, after which they settle on the bottom (2, 7, 10, 16).
Young-of-the-year and juveniles use cover and crevices within substrate as refuge against predators (19).

Sources for Table:

1. Bruce 1974.
2. Clady 1976.
3. Dryer 1966.
4. Edsall et al. 1970.
5. Faber 1970.
6. Ford et al. 1995.
7. Ghan and Sprules 1991.
8. Hanson and Qadri 1980.
9. Lawler 1963.
10. Mansfield et al. 1983.
11. McCrimmon and Devitt 1954.
12. McPhail 1997a.
13. McPhail and Lindsey 1970.
14. Morrow 1980.
15. Reckahn 1970.
16. Ryder and Pesendorfer 1992.
17. Scott and Crossman 1973.
18. Sorokin 1971.
19. Taylor 2001

Table 56. Lacustrine habitat requirements for brook stickleback.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	*H*	*H*		H	1	1		1
1-2 metres	*H*	*H*		H	1	1		1
2-5 metres	*H*	*H*		H	1	1		1
5-10 metres				H				1
10+ metres				H				1
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)	M	M			1,2,3	1,2,3		
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents	M				2,3			
Emergents	H	*M*	*M*	*M*	1,2,3	1	1	1
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Brook sticklebacks build nests on reed stems (1, 2, 3).
The young-of-the-year remain near the nest for a short period (1).

Sources for Table:

1. Scott and Crossman 1973.
2. Thomas 1962.
3. Winn 1960.

Table 57. Lacustrine habitat requirements for threespine stickleback.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	*H*	H	2,4,6,7,9	1,6,7	1,7	1,3,6,7,8
1-2 metres	H	H	*H*	H	2,4,6,7,9	1,6,7	1,7	1,3,6,7,8
2-5 metres	L			H	4,9			6,8
5-10 metres	L			M	4,9			6,8
10+ metres	L			L	4			6,8
Substrate:								
Bedrock								
Boulder								
Rubble	L	*L*		L	9	9		3
Cobble	L	*L*		L	9	9		3
Gravel	L	*L*		L	9	9		3
Sand	H	*H*		L	6,7,9	9		3
Silt	H	*H*			9	9		
Muck (detritus)	*H*	*H*		*H*	5,7	5		3
Clay (mud)	H	*H*		H	5	5		3
Limnetic				H				6,8
Cover:								
None	M				4			
Submergents	M	H	H	M	2,5,6	1	1	1,3,5
Emergents	M	H	H	M	2,5,6	1	1	1,3,5
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-the-year, J-juveniles, and A-adults

Comments and Observations:
Males build a nest out of debris and plant material in the shallow to fairly deep littoral zone (2, 4, 5, 6, 7, 9).
Newly hatched young-of-the-year stay near the nest until they are able to care for themselves (7).
Juvenile and adult threespine sticklebacks remain in the nearshore area, often associated with vegetation (1).

Sources for Table:

1. Jakobsen et al. 1988.
2. Kynard 1978.
3. Leggett 1965.
4. Lewis 1972.
5. McPhail and Lindsey 1970.
6. Morrow 1980.
7. Scott and Crossman 1973.
8. Simpson et al. 1981.
9. Wootton 1984.

Table 58. Lacustrine habitat requirements for giant black stickleback.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	*H*	H	1,3	1	1	1
1-2 metres	H	*H*	*H*	H	1,3	1	1	1
2-5 metres								
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble	L				2			
Cobble	L				2			
Gravel	H				1,2			
Sand	H				1,2,3			
Silt								
Muck (detritus)	H				2			
Clay (mud)								
Limnetic				M				2,3
Cover:								
None	L				2			
Submergents	H				2			
Emergents	H				2,3			
Overhead								
In situ	H	H	H		1	2	2	
Other	H				1			

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Giant black sticklebacks are only found in Drizzle and Mayer lakes on the Queen Charlotte Islands, and Misty Lake on Vancouver Island, BC (1).
They typically remain in shallow water (1).
Eggs are laid in nests that are built within 1.2 m of cover (2).

Sources for Table:

1. Cannings and Ptolemy 1998.
2. Moodie 1972a.
3. Moodie 1984.

Table 59. Lacustrine habitat requirements for limnetic form threespine stickleback.

Habitat Features:	**Ratings**[1] limnetic				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*		H	1,5	5		2,3,4
1-2 metres	H	*H*		H	1,5	5		2,3,4
2-5 metres				M				2,3,4
5-10 metres				M				2,3,4
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand	H				5			
Silt								
Muck (detritus)								
Clay (mud)				L				2
Limnetic				H				2,4
Cover:								
None	M				2			
Submergents	M			M	2			2
Emergents	M			L	2			2
Overhead				H				2
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Limnetic form sticklebacks occur in five lakes on Texada Island and Vancouver Islands (Haas 1998).
During the summer, limnetic sticklebacks associate with surface water next to cover, while during the winter they move to deeper water (2).
This form will hold above submergent vegetation (2).
When water levels are abnormally low, limnetic form sticklebacks move into the littoral zone and associate with vegetation (2).

Sources for Table:

1. Cannings and Ptolemy 1998.
2. Larson 1976.
3. McPhail 1988.
4. McPhail 1989.
5. Scott and Crossman 1973.

Table 60. Lacustrine habitat requirements for benthic form threespine stickleback.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	H	M	2,4	4	1,2	1,2,3
1-2 metres	H	*H*	H	H	2,4	4	1,2	1,2,3
2-5 metres			H	H			1,2	1,2,3
5-10 metres								2
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand	H				4			
Silt								
Muck (detritus)								
Clay (mud)			H	H			1,2	1,2
Limnetic								
Cover:								
None								
Submergents	H	*H*	M	M	2	4	2	2,3
Emergents	H	*H*		M	2	4		2
Overhead								
In situ	H	*H*	M	L	2	4	2	2,3
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Benthic form sticklebacks occur in five lakes on Texada Island and Vancouver Islands (Haas 1998).
Benthic form sticklebacks are found above the deoxygenated zone (2), within the littoral zone, often associated with vegetation (2, 3).

Sources for Table:

1. Cannings and Ptolemy 1998.
2. Larson 1976.
3. McPhail 1989.
4. Scott and Crossman 1973.

Table 61. Lacustrine habitat requirements for ninespine stickleback.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H		H	8,9,10,11,12	10,11		2,3,6,15
1-2 metres	m	H		H	10,11,12	10,11		2,3,6,15
2-5 metres	*L*	H		H	*1,10,11*	10,11		2,3,4,6,15
5-10 metres	L	*M*		H	1,11	*1,6,11*		2,3,4,6,10,11
10+ metres	L	*M*		H	1,11	*1,6,11*		2,3,4,6,11,12
Substrate:								
Bedrock								
Boulder								
Rubble	H			H	8			13
Cobble	H			H	8			13
Gravel	L			L	8			9
Sand	L	*L*		L	8	*7*		9
Silt	*H*	*H*			*7,9,10,11,14,15,16,17*	*11*		
Muck (detritus)	*H*	*H*			5,7,9,10,11,14,15,16,17	*11*		
Clay (mud)	H	*H*		H	5,7,9,10,11,14,15,16,17	*11*		13
Limnetic								
Cover:								
None	L	L		L	8	16		14
Submergents	H	H		H	5,7,9,10,11,12,14,15,16,17	9,11,16,17		9,16,17
Emergents	H	H		H	5,7,9,10,11,14,15	9,11,16,17		9,13,16,17
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Ninespine sticklebacks are widespread across North American, but have a limited distribution in BC (8, 13, Haas 1998).
Males build a nest on the stems of emergent plants (5, 7, 9, 10, 11, 14, 15).
Spawning has been observed at 5-40 m of water (1, 11).

Sources for Table:

1. Becker 1983.
2. Dadswell 1972.
3. Dryer 1966.
4. Emery 1973.
5. Griswold and Smith 1972.
6. Griswold and Smith 1973.
7. Lewis et al. 1972.
8. McKenzie and Keenleyside 1970.
9. McPhail and Lindsey 1970.
10. Morrow 1980.
11. Nelson 1968b.
12. Reckahn 1970.
13. Scott and Crossman 1964.
14. Scott and Crossman 1973.
15. Scott and Scott 1988.
16. Wootton 1976.
17. Wootton 1984.

Table 62. Lacustrine habitat requirements for coastrange sculpin.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres		L		L		2		1
1-2 metres		L		L		2		1
2-5 metres		M	*M*	M		2,3	2,3,5	3
5-10 metres		M	*M*	M		2,3	2,3,5	3,4
10+ metres		M	*H*	H		3	2,3,5	3,4
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel				L				1
Sand				L				5
Silt								
Muck (detritus)								
Clay (mud)				L				5
Limnetic		M	*M*	M		2,3,5	3	3
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information
[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Coastrange sculpins are found primarily in deep water (3, 4), but will move to shallower water to feed on salmon eggs (1).
This species spawning in streams over gravel substrate in riffles (5, Ricker 1960).
During the day, coastrange sculpin will rest on the bottom in deep water, and then move to the limnetic zone at night (3).

Sources for Table:

1. Foote and Brown 1998.
2. Heard 1965.
3. Ikusemiju 1975.
4. Larson and Brown 1975.
5. Scott and Crossman 1973.

Table 63. Lacustrine habitat requirements for Cultus pygmy sculpin.

Habitat Features:	**Ratings**[1]				**Sources**[2] **Sources**			
Categories[3]	S	Y	J	A	S	Y	J	A
Categories[2]								
0-1 metres				*H*				1,2
1-2 metres				*H*				1,2
2-5 metres	*H*			*H*	3			1,2
5-10 metres	*H*			*H*	3			1,2
10+ metres	*H*			*H*	3			1,2
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Pelagic				H				1,2
Limnetic								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Pygmy sculpin occur in Cultus Lake, BC and Lake Washington, WA (3, Lee et al. 1980, McPhail and Lindsey 1986).
They are found in the limnetic zone, in the mid-water column and deep water (1, 2).
Spawning supposedly occurs in deep water (3).

Sources for Table:

1. Coffie 1998.
2. Larson and Brown 1975.
3. Ricker 1960.

Table 64. Lacustrine habitat requirements for prickly sculpin.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres			M	H			1	1,3,5,6
1-2 metres			H	H			1	1,3,5,6
2-5 metres			H	H			1	1,3,5,6
5-10 metres			H	H			1	1,3
10+ metres			M	H			1	1,2,7
Substrate:								
Bedrock			H	H			1	1
Boulder			H	H			1	1
Rubble			H	H			1	1
Cobble			H	H			1	1
Gravel			H	H			1	1
Sand			H	H			1	1
Silt								
Muck (detritus)								
Clay (mud)			H	H			1	1
Limnetic		L				1		
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Prickly sculpins spawn in streams (Scott and Crossman 1973).
In streams, young-of-the-year form schools and feed on plankton for 30-35 days, before transforming to a benthic form (4).
Young-of-the-year have been caught in the limnetic zone of lakes (4).

Sources for Table:

1. Broadway and Moyle 1978.
2. Ikusemiju 1975.
3. Northcote 1954.
4. Northcote and Hartman 1959.
5. Patten and Rodman 1969.
6. Ricker 1941.
7. Simpson et al. 1981.

Table 65. Lacustrine habitat requirements for mottled sculpin.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H	H	2	2,3	2	1,2
1-2 metres			H	H			2	1,2
2-5 metres				H				1,2
5-10 metres				H				1
10+ metres				H				1
Substrate:								
Bedrock								
Boulder				H				1
Rubble			H				2	
Cobble								
Gravel								
Sand				H				1
Silt								
Muck (detritus)								
Clay (mud)		H				3		
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ			H				2	
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Mottled sculpin spawn in very shallow water (< 1 m) (2).
Young-of-the-year and juveniles remain in very shallow water (2, 3).
Adults can be found to 15 m deep (1).

Sources for Table:

1. Emery 1973.
2. Lyons 1987.
3. Scott and Crossman 1973.

Table 66. Lacustrine habitat requirements for slimy sculpin.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	M	M	9	7	5	2,4,5,6,8
1-2 metres	H	H	M	M	9	7	5	2,4,5,6,8
2-5 metres			H	H			5,7	2,3,5,6,7,8
5-10 metres			H	H			5,7	2,5,6,7,8,10
10+ metres			H	H			1	1,2,3,6,10
Substrate:								
Bedrock								
Boulder								
Rubble			H	H			5	5
Cobble			H	H			5	5
Gravel	H	H	H	H	9	7	5	4,5
Sand	H	H	H	H	9	7	5	3
Silt								
Muck (detritus)								
Clay (mud)			H	H			5	5
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ	H	H			9	7		
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
In higher latitude lakes, slimy sculpin inhabit shallower water (< 10 m) compared to more southern lakes where they can be found at depths of 80 m (1, 5, 6).
Distribution within lakes depends on thermal stratification (7, 8).
Slimy sculpin will move into very shallow water to feed on fresh salmon eggs (4).
Slimy sculpin spawn in streams or stoney lake shores (6, 7).

Sources for Table:

1. Brandt 1986.
2. Dryer 1966.
3. Emery 1973.
4. Foote and Brown 1998.
5. McDonald et al. 1982.
6. McPhail and Lindsey 1970.
7. Mohr 1984.
8. Mohr 1985.
9. Morrow 1980.
10. Scott and Crossman 1973.

Table 67. Lacustrine habitat requirements for torrent sculpin.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres				*H*				1,3,4
1-2 metres				*H*				1,3,4
2-5 metres				*H*				1,3,4
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble				H				2,4
Cobble				H				2,4
Gravel				H				2,4
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Typically, torrent sculpins are found in riffles of streams (2).
In lakes, torrent sculpins are found in the upper littoral zone over rocky substrate (1, 2, 3, 4).

Sources for Table:

1. Northcote 1954.
2. Page and Burr 1991.
3. Scott and Crossman 1973.
4. Taylor 2001.

Table 68. Lacustrine habitat requirements for spoonhead sculpin.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres								
1-2 metres								
2-5 metres				M				1
5-10 metres				M				1
10+ metres				H				1,2,3,4,5,6,7,8
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand								
Silt								
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents								
Overhead								
In situ								
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Spoonhead sculpins are a deep water species (1, 2, 3, 4, 5, 6, 7, 8).
Spoonhead sculpins have a wide distribution, but low abundance within any one location (6).
They also occur in rocky, small, fast streams (Page and Burr 1991).

Sources for Table:

1. Dadswell 1972.
2. Deason 1939.
3. Delisle and Van Vliet 1968.
4. Dryer 1966.
5. Dymond and Scott 1941.
6. McPhail and Lindsey 1970.
7. Ryder et al. 1964.
8. Scott and Crossman 1973.

Table 69. Lacustrine habitat requirements for pumpkinseed.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*	H	H	5	5	1,2	1,4
1-2 metres			H	H			1,3	1,4
2-5 metres			M	H			3	2
5-10 metres				M				2
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble	H	*H*		H	5	5		2
Cobble	H	*H*	H	H	5	5	1	1
Gravel	H	*H*			5	5		
Sand	H	*H*			5	5		
Silt	H	*H*			5	5		
Muck (detritus)	H	*H*			5	5		
Clay (mud)	H	*H*			5	5		
Limnetic								
Cover:								
None								
Submergents								
Emergents	H	*H*	H	H	5	5	4	4,5
Overhead								
In situ	H	*H*	M	M	5	5	1	1,2
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Adults inhabit a range of depths from 0-70 m (1, 2, 3, 5, 6).
Typically, pumpkinseeds are found in shallow, vegetated areas of ponds, small lakes, bay of large lakes, and slow areas of large rivers (1, 2, 5).

Sources for Table:

1. Brown et al. 2000.
2. Emery 1973.
3. Jeppson and Platt 1959.
4. Reckahn 1970.
5. Scott and Crossman 1973.

Table 70. Lacustrine habitat requirements for smallmouth bass.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H	L	6	2	2	2,3
1-2 metres	H	H	H	M	6	2	2	2,3
2-5 metres	H			H	6			1,3,6
5-10 metres	H			H	6			1,3,6
10+ metres				*M*				6
Substrate:								
Bedrock								
Boulder								
Rubble	H			H	6			3,4,5,6
Cobble	H		H	M	6		2	2,4,5,6
Gravel	H				6			6
Sand	H	H			6	2		6
Silt		H				2		
Muck (detritus)								
Clay (mud)								
Limnetic								
Cover:								
None								
Submergents								
Emergents	L		M	M	6		3	3,6
Overhead								
In situ	H		H	H	6		2	2,3,4,6
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Typically, smallmouth bass are found in small, shallow lakes (2, 3, 4, 6, Johnson et al. 1977).

Sources for Table:

1. Beamesderfer and Rieman 1991.
2. Brown et al. 2000.
3. Emery 1973.
4. Hubert and Lackey 1980.
5. Paragamian 1976.
6. Scott and Crossman 1973.

Table 71. Lacustrine habitat requirements for largemouth bass.

Habitat Features:	**Ratings[1]**				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	*H*		Nil	2	2		1
1-2 metres	H	*H*		Nil	2	2		1
2-5 metres				Nil				1
5-10 metres			*H*	H			2	2
10+ metres			*H*	H			2	2
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel	M	*M*			2	2		
Sand	M	*M*	*H*	*H*	2	2	2	2
Silt	H	*H*	*H*	*H*	2	2	2	2
Muck (detritus)	*H*	*H*	*H*	*H*		2	2	2
Clay (mud)	H	*H*	*H*	*H*	2	2	2	2
Limnetic								
Cover:								
None								
Submergents	H	*H*	*H*	H	2	2	2	2
Emergents	H	*H*	*H*	H	2	2	2	2
Overhead								
In situ	H	*H*	*H*	H	2	2	2	2
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Largemouth bass are introduced to BC (2).
Largemouth bass are found in the deep littoral zone of warm, small lakes, bays of large lakes, yet rarely in large, slow rivers (1, 2, Beauchamp et al. 1995).

Sources for Table:

1. Jeppson and Platts 1959.
2. Scott and Crossman 1973.

Table 72. Lacustrine habitat requirements for black crappie.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	*H*	H	2	2	2	1,2
1-2 metres		*H*	*H*	H		2	2	1,2
2-5 metres			*H*	H			2	1,2
5-10 metres								
10+ metres								
Substrate:								
Bedrock								
Boulder								
Rubble								
Cobble								
Gravel								
Sand	H	H	*H*	H	2	2	2	2
Silt	H	H	*H*	H	2	2	2	2
Muck (detritus)	H	H	*H*	H	2	2	2	2
Clay (mud)	H	H	*H*	H	2	2	2	2
Limnetic								
Cover:								
None								
Submergents								
Emergents	H	*H*	*H*	H	2	2	2	2
Overhead								
In situ	H				2			
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Black crappies have been introduced to BC (2).
Typically, they are found in vegetated areas in clear, calm and warm water of ponds, small lakes or shallow bays of large lakes and slow large rivers (2).

Sources for Table:

1. Jeppson and Platts 1959.
2. Scott and Crossman 1973.

Table 73. Lacustrine habitat requirements for yellow perch.

Habitat Features:	Ratings[1]				Sources			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H	M	11	9	6,7,9,11	3,6,9,10,11
1-2 metres	H	H	H	H	11	9	6,7,8,9,11	3,6,8,9,10,11
2-5 metres	H	M	H	H	11	9	2,6,8,9,11	1,2,3,6,8,9,10,11
5-10 metres			L	H			2	1,2,3,4,10,11
10+ metres			L	H			2	1,2,3,4,5,10,11
Substrate:								
Bedrock								
Boulder				H				3
Rubble								
Cobble								
Gravel	M	*M*	*H*	H	11	11	11	11
Sand	M	*M*	*H*	H	11	11	11	3,11
Silt			*H*	H			11	11
Muck (detritus)			*H*	H			11	11
Clay (mud)								
Limnetic			*M*	M			11	11
Cover:								
None								
Submergents								
Emergents	H	*H*	*M*	M	11			3,11
Overhead								
In situ	H	*H*		H	11			3
Other								

[1] Ratings are Nil, L-Low, M-Medium, H-High, Italicised-rating based on related information
[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Yellow perch have expanded their range into BC (11).
Yellow perch inhabit warm and cool lakes, ponds and slow-flowing rivers (11).

Sources for Table:

1. Beauchamp et al. 1995.
2. Berst and McCombie 1963.
3. Emery 1973.
4. Ferguson 1958.
5. Hergenrader and Hasler 1968.
6. Jeppson and Platts 1959.
7. Johnso 1977.
8. Kelso 1974.
9. Lyons 1987.
10. Reckahn 1970.
11. Scott and Crossman 1973.

Table 74. Lacustrine habitat requirements for walleye.

Habitat Features:	**Ratings**[1]				**Sources**			
Categories[2]	S	Y	J	A	S	Y	J	A
Depths:								
0-1 metres	H	H	H	M	2,7	3,4,7,19	5,6,8	8,10
1-2 metres	H	H	H	M	2,7	7,10	5,6,8	8,10
2-5 metres	H	H	H	H	2,7	7,10	8	1,10
5-10 metres	H	H	H	H	7	10	8	1,10
10+ metres	M	H	H	H	7	10	8	1,10
Substrate:								
Bedrock								
Boulder	H				7,10			
Rubble	H				2,7,10			
Cobble	H				7,10			
Gravel	H				2,7,10			
Sand	Nil				7			
Silt								
Muck (detritus)	Nil			Nil	7			1
Clay (mud)	Nil				7			
Limnetic		H				3,4,7,10		
Cover:								
None								
Submergents	L			Nil	10			2
Emergents				H				10
Overhead			H	H		4		2,10
In situ			H	H		4		2,10
Other			H	H				2

[1] Ratings are Nil, L-Low, M-Medium, H-High. Italicised-rating based on related information

[2] Categories are S-spawning, Y-young-of-year, J-juveniles, and A-adults

Comments and Observations:
Walleye are both introduced and native to BC (10).
Walleye are sensitive to bright light (10) and are therefore found in fairly turbid small and large lakes and reservoirs (5, 6, 10, Dymond and Scott 1941, Rawson 1951, Beasenderfer and Rieman 1991).
They are found in lakes that have a large percentage of the lake area within the littoral zone (5).

Sources for Table:

1. Colby and Ryder 1979.
2. Ford. et al. 1995.
3. Houde 1969.
4. Houde and Forney 1970.
5. Johnson 1977.
6. Jones et al. 1994.
7. Martin 1956.
8. Ryder 1977.
9. Scherer 1971.
10. Scott and Crossman 1973.

Table 75. Freshwater species in BC that are either not found in lakes, or have insufficient lake habitat requirement information.

Species/form	**Comments and Observations**	**Sources**
Western brook lamprey	Does inhabit lakes, but no information is available. This species spawns in streams. Ammocoetes burrow in the mud and silt at the stream margins and remain there for up to six years.	24 17 20
Pacific lamprey	This species is anadromous. There are lake-dwelling populations of Pacific lamprey, and all that is known is that they are predators on fish.	6 4,5,20
Green sturgeon	This species inhabits brackish waters along the coast of BC and Vancouver Island and the Queen Charlotte Islands, and is rarely found in freshwater.	9,24,25
American shad	This species is anadromous. The adults spawn in the water column and the eggs drift downstream towards the ocean. Adults migrate back to the ocean immediately after spawning.	24 1,13,24
Flathead chub	This species inhabits muddy, turbid, flowing main channel rivers, and seldom is found in lakes or ponds.	16,18,24
Umatilla dace	This species inhabits warm, fast flowing, clean, bouldery rivers. Umatilla dace have been collected in reservoirs where there is large substrate and a recordable current.	3,12,19 11
Bridgelip sucker	Although this species is found in slow, sand and mud bottomed areas of rivers and lakes, it is most common in small, swift rivers that have abundant gravel to rocky substrate.	24
Mountain sucker	This species is only occasionally found in lakes. Mountain sucker are most commonly found in cool, small, moderate current mountain streams < 12 m wide and 1m deep.	23 2
Surf smelt	The freshwater range for this species is only within the lower Fraser River.	9
Eulachon	This species only moves short distances into coastal rivers and streams to spawn, and otherwise are a marine species.	24
Arctic cisco	This species does not general inhabit lakes. They are anadromous and are found in brackish water along the Arctic coastline.	24
Pink salmon	This species is anadromous, and only ventures short distances upstream to spawn. young-of-the-year return to the ocean almost immediately after they emerge from the spawning gravel.	8,10 14
Chum salmon	This species is anadromous, and only ventures short distances upstream to spawn. young-of-the-year return to the ocean almost immediately after they emerge from the spawning gravel.	15,22 14,15
Steelhead	This form occurs in most large coastal streams and river, and also extends into the upper waters of the Fraser and Thompson Rivers. This species is anadromous. Summer run steelhead may utilize lakes as waiting grounds before spawning, however the habitat use is unknown.	7 7 26
Shorthead sculpin	In BC, primarily a river species. Shorthead sculpin caught in deep water in Lake Michigan	24 21

Sources for Table:

1. Bradbury et al. 1999.
2. Campbell 1992.
3. Cannings and Ptolemy 1998.
4. Carl 1953.
5. Coots 1955.
6. Docker et al. 1999.
7. Ford et al. 1995.
8. Godfrey et al. 1954.
9. Haas 1998.
10. Heard 1991.
11. Hughes and Peden 1988.
12. Hughes and Peden 1989.
13. Leim and Scott 1966.
14. Levy and Northcote 1982.
15. Mason 1974.
16. McAllister 1961.
17. McIntrye 1969.
18. Olund and Cross 1961.
19. Peden and Orchard 1993.
20. Pletcher 1963.
21. Potter and Fleischer 1992.
22. Salo 1991.
23. Scott 1966.
24. Scott and Crossman 1973.
25. Slack and Stace-Smith 1996.
26. van Dishoeck et al. 1998.

APPENDIX 1 – GLOSSARY OF TERMS

Adhesive – Sticking or clinging.

Adult – Life stage of fish where they have matured and are able to reproduce.

Aquatic plants/vegetation – Plants whose photosynthetically active parts are permanently, or at least for several months each year, submerged in, or floating on, freshwater.

Alevin – Embryonic development stage of salmonid fish species which occurs between hatching from the egg, and before the absorption of the yolk sac and emergence from spawning gravel.

Allopatric – Species inhabiting geographically separated areas from other stocks of the same species.

Ammocete – The larval form of lampreys.

Amphidromous – Fish which breed in freshwater, and remain in freshwater for some time before entering the ocean.

Anadromous – Fish which breed in freshwater but spend most of their adult life at sea, also commonly referred to as sea-run.

Aquatic – Living in water (freshwater, estuarine or marine).

Benthic – Living on, in or near the bottom of aquatic habitats.

Cover – Features within the aquatic environment that may be used by fish for protection (or refuge) from predators, competitors and adverse environmental conditions.

Demersal – Living on or near the bottom of a lake, often said of fishes and fish eggs.

Depth – Distance from the water surface.

Detritus – Organic material from dead organisms (plant and/or animal).

Diel – Within a 24 hour period, usually including night and day.

Emergent vegetation – Aquatic plants which grow on water-saturated or submerged soils and extend their stems and leaves above the surface of the water (eg. cattails, grasses, sedges and rushes.

Estuary – A semi-enclosed body of water which has a free connection with the open ocean and within which saltwater is measurably diluted with freshwater derived from land drainage.

Eutrophy – Water rich in nutrients.

Exotic species – Species introduced to an area where it does not occur naturally.

Fish habitat – Aquatic areas on which fish depend either directly or indirectly in order to carry out their life processes.

Hydrid – The offspring of parents of different species. Hybrids are generally infertile or have reduced viability, and reproduction is minimal.

Hypolimnion – The poorly illuminated lower region of a stratified lake characterized by denser, colder water protected from wind action, lies below the metalimnion and overlies the profundal zone.

Incubation period – The time interval between egg laying and hatching.

Indigenous species – Naturally occurring species of native or local origination (ie. not imported or introduced.

Isotherm – A line joining points of equal temperature.

Juvenile – Young fish, older than one year, fundamentally like adults in appearance, but smaller and reproductively inactive.

Lacustrine habitat – Habitat contained within a pond or lake.

Landlocked – Populations of fish that are prevented from making return migrations to the ocean because of natural obstructions. It also categorizes fish that live their entire life cycle within freshwater regardless of whether they have access to the ocean.

Larvae – Organisms which at birth or hatching are fundamentally unlike their parents and must pass through metamorphosis before assuming adult characteristics.

Lentic – Refers to standing water, as in ponds and lakes.

Limnetic – Open-water regions, either middle or surface water levels, that are not directly influenced by the shore or bottom.

Littoral – The marginal region of a body of water and is usually defined by the band from zero depth to the maximum depth of light penetration. Often this area is shallow, subject to fluctuating water temperatures and erosion of shore material through wave action and the grinding of ice.

Lotic – Flowing water.

Macrophytes – Rooted aquatic plants.

Metamorphosis – Change in form and structure which fish undergo from the embryo to adult stages.

Migration – The deliberate movement of fish from one habitat to another.

Natal river – The river or stream in which a fish was spawned.

Native species – Fish that originate in the area in which they live (refer to indigenous species).

Nursery (Rearing) habitat – The portion of fish habitat which provides food and cover for young fish

Oligotrophic – Condition of water being poor in plant nutrients.

Ontogenetic – Size-related shifts of life history changes that occur during the growth and development of an individual.

Organic – Derived from a living organism.

Organic debris – Material in a water course that is of organic origin including algae, aquatic plants, logs, trees, and other woody material.

Overhanging (Riparian) cover – Cover provided by vegetation such as grasses, shrubs, alders and other low-story trees adjacent to the waterbody and up to 1 m above the water surface.

Overhead cover – Riparian cover overhanging littoral habitat, undercut banks, woody debris at the surface providing shade, crevices etc.

Piscivorous – Fish-eating.

Plankton – Small aquatic plants and animals, sometimes microscopic, drifting within the surrounding water.

Population – A group of individuals of a species occupying the same waters during at least part of their life cycle.

Profundal – The deep, cold region of lakes where currents are at a minimum and where light is much reduced, comprises the deep water and the lake bottom.

Redd – The nest of salmonid fishes where the eggs are deposited.

Resident fish – Fish which remain in freshwater throughout their entire life cycle (non-anadromous).

Shoal – Offshore shallow areas.

Silt – Very fine sediment particles that can be carried or moved by stream currents and deposited in slower moving water. This material is particularly harmful to invertebrates and extremely detrimental to spawning habitat.

Smolt – A salmonid having undergone physiological changes to cope with shifting from freshwater to a marine environement, usually refers to salmonids exhibiting silvery coloration and downstream movement to the ocean.

Spawning habitat – Habitat used by reproductively active fish for spawning and incubation of fertilized eggs.

Submergent vegetation – Aquatic plants that grow entirely below the water's surface (eg. pondweeds, bladderwart) and includes numerous mosses and macroalgae.

Substrate – The materials of which a stream or lake bottom is comprised including, bedrock, boulder, rubble, cobble, gravel, sand, silt, detritus and mud.

Sympatric – Species inhabiting the same or overlapping geographic areas and are not denied the opportunity to breed by any geographic barrier.

Thermocline – The region in a lake where the water temperature changes rapidly, usually at a rate of more than 1°C per meter depth.

Threatened species – Indigenous taxa that are likely to beome endangered, if factors affecting their vulnerability are not reversed (Cannings and Ptolemy 1998).

Tributary – Refers to any stream that flows into another, larger stream above its confluence with saltwater, or a lake (river mouth).

Upwelling – The motion or movement of water in the upward direction.

Vulnerable species – indigenous species that are not immediately threatened but are particularly at risk for reasons including low or decling abundance, a restricted distribution or occurrence at the fringe of their global range (Cannings and Ptolemy 1998).

Watershed – A region or area bounded peripherally by a water parting and draining ultimately to a particular watercourse or body of water.

Young-of-the-year – Essentially the first year of life for a fish (age 0+).